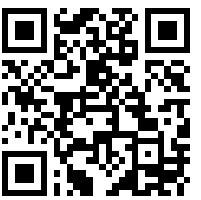

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Contents of R.A. Journal, October, 1915.

TRANSLATIONS.

Monomial Formulas for Pressure and Velocity for Ordnance and Small Arms Firing Colloid Powders

By Captain J. H. Hardcastle, *pac.*, R.A.

Introductory.

In a previous article in R.A. Journal November, 1909, I showed how to reduce the labour of calculating problems of interior ballistics when using Ingalls' method, and how to adapt his formulas for slide rule working. It was a great pleasure, therefore, to read in the preface to Colonel Ingalls' third edition of "Interior Ballistics," published in New York in 1912, that he approved of the adaptation, and had added a supplementary table of the principal X functions in natural numbers. It is now proposed to show how to shorten his method even more, and then to piece on to it an independent expression, adapted from Charbonnier's formula, for the maximum pressure, and so to obtain formulas of the greatest simplicity for ascertaining the effect of varying any of the six principal dimensions of the gun and charge, viz:—the weight of the charge and of the shot, the capacity of the chamber and the size of the cordite, the shot travel and the calibre.

It is also proposed to examine the accuracy of these formulas by comparing them with actual firing results, and to correct them where necessary to correspond with practice, and finally to make such remarks upon them as spring naturally from the investigation.

The reason for deciding to cast the formulas into the monomial form of a set of percentage alterations is that the formulas derived from purely mathematical considerations are of such complexity that the general drift of them is hidden by the symbols, so that the effect of varying the charge, for instance, by ten per cent. is not readily visible, or quickly calculated. The assumptions also which underlie the mathematical treatment are very numerous, and are mostly incapable of experimental proof. Each of them has its effect on the numerical value of the pressure or velocity to be determined, and so it is unsafe to use those determinations by themselves for guns or charges differing greatly from the usual standard. For many years to come theory and practice must be content to advance in step with one another, and a prophecy derived from either alone must not be trusted too far.

The conditions of a closed vessel experiment are different from those in the gun, and a comparison of the points of accord and of

difference is to be found in Charbonnier's recent volume of l'Encyclopédie Scientifique "Balistique Intérieure" (Paris, 1908, 5 francs). The third and fourth chapters, composing the whole of the second part, are devoted to these points, and the contents of these chapters go far to justify the use of monomial formulas of admittedly empirical type, in preference to binomial or multinomial formulas more elegant in shape, but containing in each term at least one factor which can only be determined by experiments of such delicacy that they have not yet been performed in a completely satisfactory way.

I may perhaps be excused for reminding some of my readers that a monomial is the simplest form an equation can take and that $y = a x^n$ is a typical form. In colloquial English this equation states that one per cent increase or decrease in x causes n per cent increase or decrease in y. It can also be written $\log y = \log a + n \log x$, so that when plotted on a sheet of logarithmic paper the graph is a straight line. In this article the expression monomial is confined to those equations containing only numerical indices and coefficients attached to the simple ballistic quantities. For convenience the table of symbols and their meanings is reprinted from my former article as Appendix I. The subject matter also is distributed under the following sections.

Section I. First simplification. Determination of point of complete combustion.

Section II. Second simplification. A monomial to connect P_m and V. 3 Examples.

Section III. Third simplification. Introduction of l_0.

Section IV. Introduction of an independent expression for P_m. Table I.

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Section VIII. A monomial for the point of complete combustion Table V, of indices of $\bar{u}$.

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Section X. Application of the formulas to small arms design. A change of notation. Two examples Table IX.

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Section XII. Obiter dicta.

Section XIII. Recapitulation and conclusion.

Appendix I. Symbols and their meanings.

Appendix II. Abridged table of functions.

Appendix III. Detailed example of method of obtaining indices.

SECTION I.

First simplification.

Determination of point of complete combustion.

Ingalls' method involves two separate assumptions, the nature of each being such that it fits into the scheme of the other. One assumption is that the velocity of combustion varies as the square root of the pressure, and the other is that the ratio of the specific heats is four-thirds. Their point of junction is in the X_0 function, which is the integral arising from the employment of each of these two assumptions, which integral itself is admirably suited for the basis of a set of tables.

Making both these assumptions, the tabular method becomes possible, and denying either of them renders this particularly simple method impossible.* Neither of them is demonstrably true, and many writers deny them both; but it must be admitted that when combined they form a working hypothesis, or a tool capable of giving useful results. which cannot be obtained so easily by any other known method. In particular, they enable continuous pressure and velocity curves to be drawn from the breech to the muzzle with substantial accuracy and great rapidity.

In the former article, formula 9 reads:

$$\bar{X}_0=\Sigma+\sqrt{\Sigma^2-3{\cdot}05\ \Sigma}=f\ (\Sigma)$$

where the part under the root vanishes in the case of tubular propellants, and

$$\Sigma=\frac{2{\cdot}16\ W\ V^2}{10^6\ w\ a^2\ P_m\ X_2}$$

The first simplification begins by the tabulation of X_0 against Σ once and for all, and the insertion of an extra column for f (Σ) in the Table of X functions against x. As this article only deals with expressions containing the X_0 and X_2 functions, and as experience has shown that they need only be got out to three significant figures, and for whole numbers of x from 1 to 20, a much abbreviated table is sufficient, and is inserted as Appendix II, together with an abbreviated table of Δ against a^2.

To obtain $\bar{u}$ the point where combustion is completed, x_0 is evaluated from

$$x_0=\frac{u_0\ d^2}{2{\cdot}94\ a^2\ w}$$

and the value X_2 corresponding to x_0 is taken from Appendix II. Σ is then evaluated from the formula just given, and in the case of the explosive being in the form of cords, x is read off in the table against the value of Σ so found and is looked out in the $f\ (\Sigma)$ column. If the explosive is in the form of long tubes $\Sigma = X_0$ and the value of x is read off against the same value, but looked out in the X_0 column. This value of x is then $\bar{x}$ and this is turned into $\bar{u}$

* But see "Journal of the U.S.A. Artillery," November, 1913, p. 275, where Col. Ingalls modifies the solution for ratios of the specific heats of three-halves, five-fourths and seven-sixths, in addition to four-thirds.—*J.H.H.*, 4/4/14.

feet of travel by the formula just given for x_0. The whole process takes, perhaps, two minutes, and the result is very reliable, provided that the physical measurements of the gun and charge have been given accurately.

It sometimes happens that the calculation makes the combustion of cords complete a good many calibres outside the muzzle. It is as well then to apply the formula for the thickness burnt after any travel

$$\frac{l}{l_0} = \frac{X_0}{\bar{X}_0}$$

and put in the value of X_0 at the muzzle. It will then be seen what size the unburnt cords are at the muzzle, and thence the weight of unburnt cordite. This latter weight will generally be found to be insignificant, although the distance to complete combustion seems quite large.

If the propellant is in the form of strips several times as wide as they are thick, it is possible to calculate a special table of $f(\Sigma)$ for strip, provided that the width is known in terms of the thickness, but this has not been done because a value of $\bar{X}_0$ intermediate between that for cord and that for strip can be estimated so easily after consulting Ingalls' chapter on the geometry of the grain, and working one or two examples.

No examples are given of the determination of the point of complete combustion, as there were three examples in the former article.

SECTION II.

Second simplification.

A monomial to connect maximum pressure and muzzle velocity.

The next simplification is to reduce the formula already given connecting Σ or X_0, V and P_m to a simple monomial. Although this is impossible by rigid methods, as stated by all writers, nevertheless, for practical purposes, it is a very simple business, and requires only a sheet of logarithm paper. On such a sheet the table of Δ and a^2 is plotted, or their logarithms are plotted on ordinary squared paper, and the equation is written down at once. The useful values of Δ are round about 0·4 and 0·5. If the value of a^2 obtained from $\log a^2 = 0{\cdot}699 - 1{\cdot}4 \log \Delta$ are compared with the values given in the appendix, it will be seen that the results correspond between the values $\Delta = 0{\cdot}27$ and $\Delta = 0{\cdot}65$.

Also

$$\Delta = \frac{27{\cdot}73\ w}{C}$$

and the monomial is

$$a^2 = \left[\bar{3}{\cdot}679\right] C^{1{\cdot}4} \Big/ w^{1{\cdot}4}$$

or in logarithmic form

$$\log a^2 = \bar{3}{\cdot}679 + 1{\cdot}4 \log C - 1{\cdot}4 \log w.$$

or in percentages, 1% increase of C or decrease of w produces 1·4% increase of a^2.

Putting this into the expression

$$x_0 = \frac{u_0 d^2}{2{\cdot}94\, a^2 w}$$

the following expression in logarithmic form results:

$$\log x_0 = 1{\cdot}853 + \log u_0 + 2 \log d + 0{\cdot}4 \log w - 1{\cdot}4 \log C.$$

Similarly plotting X_0 and X_2 against x, and Σ against X_0 within the useful range of values

$$X_0 = 3{\cdot}24\ x^{0{\cdot}38}$$
$$X_2 = 0{\cdot}31\ x^{0{\cdot}24}$$
$$\Sigma = 1{\cdot}16\ \overline{X_0}^{0{\cdot}7}$$

or

$$\log X_0 = 1{\cdot}214 + 0{\cdot}38 \log u + 0{\cdot}76 \log d + 0{\cdot}15 \log w - 0{\cdot}53 \log C$$
$$\log X_2 = \bar{1}{\cdot}935 + 0{\cdot}24 \log u + 0{\cdot}48 \log d + 0{\cdot}10 \log w - 0{\cdot}34 \log C$$
$$\log \Sigma = 0{\cdot}915 + 0{\cdot}26 \log u + 0{\cdot}52 \log d + 0{\cdot}11 \log w - 0{\cdot}37 \log C$$

If the values of X_0, X_2 and Σ obtained by these approximations are compared with the tabular values in Appendix II, it will be seen that the greatest error of the approximate values is about two per cent., and that the average error is negligible.

To reduce the formula connection Σ or X_0, V and P_m to a monomial it is now only necessary to substitute the approximate values in the original formula, and then the ratio between the muzzle velocity and the maximum pressure is expressed in terms of dimensions which can be directly and accurately measured without firing. The diameter of the bore in inches, the length of the rifling in feet, the weight of the charge and of the shot in lbs., and the chamber volume in cubic inches, are quantities capable of measurement within one part in a thousand, and are generally so measured with the exception of the chamber.

The measurement of this latter to the accuracy required for purposes of calculation is not by any means a simple matter, as the volume required is the volume occupied by the consumable part of the charge, and by the air volume behind the shot when the latter is just sealing the bore. The volume of the card wads, of the crusher guages, and of the brass case must be deducted, and the space between the outside of the brass case and the walls of the chamber presently to be occupied by the expanded case, must be included. With small arms having a side pressure piston the volume of the recess cut for the piston up to the piston gas cheek must be filled with unconsumable grease, or else included in the chamber volume. A service crusher guage bulks about two cubic inches, which is four per cent. of a chamber colume of fifty cubic inches, and one inch of ramming is 113 cubic inches of chamber in a 12-inch gun. With fixed ammunition, whether for Q.F. or small arms, there is a further complication owing to the existence of two forcements, the first to cause the shot to leave the brass case and the second to engrave it, between which two there is a space called the free travel. The effect also of varying the method of ignition, in French

l'amorçage, is notorious, and this includes the cap composition, the size of the fire-holes and the strength of the striker spring or electric current.

Before substituting the new values in the equation connecting V and P_m by means of Σ or $\overline{X}_0$ it will be clearer to re-arrange and make P_m the argument thus:

$$P_m = 2{\cdot}16\ W\ V^2 / 10^6\ w\ a^2\ X_2\ \Sigma$$

Then for tubes using the value of $\overline{X}_0$

$$P_m = [\bar{5}{\cdot}507]\ W\ V^2\ w^{0{\cdot}15} / u^{0{\cdot}62}\ d^{1{\cdot}24}\ C^{0{\cdot}53}$$

And for cords, using the value of Σ

$$P_m = [\bar{5}{\cdot}806]\ W\ V^2\ w^{0{\cdot}19} / u^{0{\cdot}50}\ d^{1{\cdot}00}\ C^{0{\cdot}69}$$

In both these expressions the index of u is formed by the additions of the indices of u in the expressions for X_2 and Σ or $\overline{X}_0$. In the latter u refers to the point where combustion is complete, and is properly written $\bar{u}$, so that the actual expression for P_m is true only when combustion is complete exactly at the muzzle.* If combustion is completed at $\frac{1}{m}$ of the shot travel, the maximum pressure is reduced by a factor approximately equal to $\sqrt[3]{m}$. These expressions for P_m give results not far from the results of firing, as the following three examples show.

EXAMPLES.

Calculate the maximum pressure for these three guns.

	(1)	(2)	(3)
d	12·0	0·303	0·220
W	850	0·0250	0·010
w	254	0·00543	0·0032
C	18,000	0·210	0·126
u	32	1·94	1·5
V	2600	2450	2760

(1) is a former 12″ B.L. (2) is the new Mark VII cartridge for the service rifle, and (3) is a new Savage High Velocity rifle reported upon by "The Field" on April 20th, 1912, from which the details are taken, except the chamber, which I measured myself.

(1). Fires cordite M.D. (2). Fires M.D. Tubular. (3). Fires a chopped tube about 0·03 inch thick, and 0·08 inch in diameter, giving a diminishing surface of combustion almost exactly similar to that of cords, so that the cord formula is used. The Savage Arms Co., write that the pressure taken at their factory in Utica is 45,000 lbs., per inch ^{2}, and it has been said that the same velocity can be

* Writing for the "Journal R.U.S.I.," July 1912, I fell into this trap myself on p. 984 whilst running out the calculations for a 6 m/m rifle. The suggested muzzle velocity of 3300 fs. requires a prohibitive pressure really.

got with the same weight of Mark I cordite size 3¾ with a pressure of 18 tons per inch ^{2}.

The calculations are as follows:

(1).

Constant log	$\bar{5}\cdot806$	$0\cdot50 \log u$	$0\cdot753$	
log W	$2\cdot929$	$\log d$	$1\cdot079$	
2 log V	$6\cdot830$	$0\cdot69 \log C$	$2\cdot935$	
$0\cdot19 \log w$	$0\cdot457$			$4\cdot767$
	$6\cdot022$			
	$4\cdot767$			
$\log P_m$	$1\cdot255$	$P_m = 17\cdot99$ tons per inch^2		

This is about the correct pressure and indicates that combustion is complete at the muzzle.

(2)

Constant log	$\bar{5}\cdot507$	$0\cdot62 \log u$	$0\cdot178$	
log W	$\bar{2}\cdot398$	$1\cdot24 \log d$	$0\cdot604$	
2 log V	$6\cdot778$	$0\cdot53 \log C$	$0\cdot171$	
$0\cdot15 \log w$	$0\cdot110$	Negative w	$0\cdot450$	
Negative C	$0\cdot530$			$1\cdot403$
Negative d	$1\cdot240$			
	$2\cdot563$			
	$1\cdot403$			
$\log P_m =$	$1\cdot160$	$P_m = 14\cdot45$ ton per inch^2.		

The actual pressure is about 18·0 tons per inch^2. So that

$$\sqrt[3]{m} = \frac{18}{14\cdot45} = 1\cdot245 \text{ or } m = 1\cdot93$$

which may indicate that the combustion is complete at about half travel.

---

(3)

Constant log	$\bar{5}\cdot806$	$0\cdot50 \log u$	$0\cdot088$	
log W	$\bar{2}\cdot000$	$1\cdot00 \log d$	$\bar{1}\cdot350$	
2 log V	$6\cdot882$	$0\cdot69 \log C$	$0\cdot126$	
$0\cdot19 \log w$	$0\cdot096$	neg. w	$0\cdot570$	
neg. C	$0\cdot690$			$0\cdot134$
	$1\cdot474$			
	$0\cdot134$			
$\log P_m =$	$1\cdot340$	$P_m = 21\cdot88$ tons per inch^2.		

which may indicate that the reported pressure is wrong, or that

combustion is not complete at the muzzle. Experiment shows that it is not all burnt at the muzzle with this short barrel.

SECTION III.

Third simplification.

Introduction of the dimensions of the propellant.

The next, and more important simplification, is obtained by taking as another value of $\overline{X}_0$ that given in equation (10) of the former article

$$\overline{X}_0 = \frac{100\, l_0\, d^2}{3{\cdot}63\, v_c \sqrt{a^2\, W w}}$$

which introduces the size of the propellant, and gives the main result of Ingalls' method in the briefest fashion. The velocity of combustion at atmospheric pressure (v_c) is supposed to be a constant for any given powder, varying only with the composition and density. I am unable to find it constant, and have always treated it as an experimental factor, varying from 0·2 to 0·35. It will be convenient for the moment to make it about $1/4/k$ where k is a coefficient nearly equal to unity.

Substituting for a^2 its new value $[\overline{3}{\cdot}679]\ (C/w)^{1\cdot4}$
and making $v_c = 0{\cdot}251/k$

$$\overline{X}_0 = k_1\ [3{\cdot}000]\ l_0^{1.00}\, d^{2.00}\, w^{0.20} \,/\, W^{0.50}\, C^{0.70}$$

and since

$$\Sigma = 1{\cdot}16\, \overline{X}_0^{0.7}$$
$$\Sigma = k_2\ [2{\cdot}165]\ l_0^{0.70}\, d^{1.40}\, w^{0.14} \,/\, W^{0.35}\, C^{0.49}$$

Re-writing the earlier formula connecting P_m and V for tubes as

$$V^2 = 10^6 w a^2\, P_m\, X_2\, \overline{X}_0 / 2{\cdot}16 W$$

and for cords as

$$V^2 = 10^6 w a^2\, P_m\, X_2\, \Sigma / 2{\cdot}16 W$$

and substituting for X_2, a^2, Σ or $\overline{X}_0$ and taking the square root, these two expressions result:—

For tubes

$$V = k_1 \sqrt{P_m}\ [3{\cdot}140]\ l_0^{0.50}\, C^{0.18}\, u^{0.12}\, d^{1.24} \,/\, W^{0.05}\, W^{0.75}$$

and for cords

$$V = k_2 \sqrt{P_m}\ [2{\cdot}722]\ l_0^{0.35}\, C^{0.28}\, u^{0.12}\, d^{0.94} \,/\, W^{0.08}\, W^{0.67}$$

which are monomials for V in terms of P_m, and the dimensions of the gun and charge with an experimental constant nearly equal to unity. They represent with great precision the results of the two fundamental assumptions made by Ingalls that the velocity of combustion varies as the square root of the pressure, and that the ratio

of the specific heats is four-thirds. They show the variation in the ratio of muzzle energy and pressure as each of the six main dimensions are varied, and nothing else.

I have been through the ballistics of some dozens of ordnance of varying type with them and also of all the express rifles for which Eley and Kynoch advertise cartridges, and find the formulas useful when the variations are not very great, and an intelligent estimate is made of the value of the constant k_1 or k_2. The latter estimate is skilled work, and it is greatly facilitated by tabulating the particulars of guns and charges after applying the principle of mechanical similitude.* This principle reduces all particulars to a comparison with those of a unit gun, a 1 pounder of 1 inch, and thus eliminates the calibre. The weights of charge and of shot, and the volume of the chamber are divided by d^3 and become w/d^3 W/d^3 and $C/^2$ on the principle of the sectional density W/d^2 in exterior ballistics. The least dimension of the propellant ($2\ l_0$), and the shot travel $12u$ are divided by d, while V and P remain unchanged. A high power rifle is then not unlike a heavily loaded 6 inch gun with a very long shot travel.

SECTION IV.

Introduction of an Independent Expression for Maximum Pressure.

Having arrived at these tentative indices in the monomials, the next step is to adapt the formulas for use in the design of guns or charges by inserting an independent expression for P_m. Charbonnier's work leads to such an expression. In his "Balistique Intérieure", already mentioned, he gives on p. 323 as a general expression, the first term of the series for the expression for maximum pressure, when the velocity of combustion varies as the nth power of the pressure. In his notation it is:

$$(P_m)^{3-2n} = K_n \left(\frac{A f w}{\sigma}\right)^2 \frac{\mu}{c^1 - w^1}$$

where K_n is a long numerical expression involving n and the ratio of the specific heats.

A is the "vivacité" of the powder, and varies directly as the initial surface, that is inversely as Ingalls' l_0. It can be determined for each powder by closed vessel experiments.

f is the force of the powder, said to be a constant for each powder.

w is the weight of the charge; Ingalls' w.

σ is the cross section of the bore; $\pi\ d^2/4$

μ is the weight of the shot, together with a certain proportion of

* Since writing the above I have had the pleasure of reading Captain R. K. Hezlet's article in "R.A. Journal," for Nov., 1912, making great use of this principle. He really shows how necessary it is when using Ingalls's method to assume the answer by assuming a value for the force. This remark also applies to any method utilising the muzzle energy per pound.

the powder, the whole multiplied by the characteristic of the cannon, an experimental quantity; μ varies nearly as Ingalls' W.

c^1 is the volume of the chamber; Ingalls' C.

w^1 is the volume of the powder, and finally

$c^1 - w^1$ = Ingalls' wa^2 and is the total air volume, and varies as $C^{1\cdot4}/w^{0\cdot4}$.

Then by substitution

$$(P_m)^{3-2n} = \text{a numerical factor} \left(\frac{w}{d^3}\right)^{2\cdot4} \left(\frac{W}{d^3}\right)^{1\cdot0} \left(\frac{d^3}{C}\right)^{1\cdot4} \left(\frac{d}{l_0}\right)^{2\cdot0}$$

from which to determine n and the constant by the results of any actual firings which are available, and to devise experiments to verify the indices of the leading dimensions.

The following table of the value of the indices, which are all of the positive sign, corresponding to the value of n and $(P_m)^{1\cdot00}$ is useful.

TABLE I.

n	$\frac{1}{3-2_n}$	$\frac{w}{d^3}$	$\frac{W}{d^3}$	$\frac{d^3}{c}$	$\frac{d}{l_0}$
1·0	1·0	2·40	1·00	1·40	2·00
$\frac{3}{4}$	$\frac{2}{3}$	1·60	0·67	0·93	1·33
$\frac{2}{3}$	$\frac{3}{5}$	1·44	0·60	0·84	1·20
$\frac{1}{2}$	$\frac{1}{2}$	1·20	0·50	0·70	1·00

Although this is only the result of using the first term of the general expression, it should be remembered that this is by far the most important term, and in the case of propellants in the form of tubes or of wide sheets it is the only term when the forcement is taken as zero. It is therefore a very valuable guide to a first approximation.

Charbonnier gives also a binomial expression for maximum pressure with cords, which is worth mentioning here. It gives the value of the ratio between the maximum observed pressure in the gun, and in the closed vessel at the density of loading, and is found on page 274. It is of the form

$$\frac{P_m}{P_\Delta} = K \frac{1}{r} 1 - \tfrac{3}{8} \frac{\gamma - 1}{\gamma 2} \frac{\lambda}{r}$$

Where K involves the ratio of the specific heats γ, which he takes as 1·25, making K = 0·0722.

λ is here 0·5, as it is for cords.

$$r=\frac{\gamma-1}{2}\ \frac{\mu}{10\,\mathrm{fw}}\ \left(\frac{\sigma}{\mathrm{A}\mu}\right)^2$$

which varies as $\frac{l_0^2\ d^4}{\mathrm{W}\ w}$ if the velocity of combustion remains really constant.

Making these substitutions the following expression is obtained for determining the experimental constant K_1, from the results of actual firing

$$\mathrm{K}_1=16{\cdot}7\left(\frac{d^3}{\mathrm{W}}\right)\left(\frac{d^3}{w}\right)\left(\frac{l_0}{d}\right)^2\left\{1\pm\sqrt{1-1{\cdot}67\frac{\mathrm{P_m}}{\mathrm{P}_\Delta}}\right\}$$

where the positive sign must be rejected and the negative sign employed.

This expression has not been tried for ordnance, but for express and military rifles log K_1 is about $\bar{2}{\cdot}16$ when firing size 3¾, with the chamber volumes correctly measured. The values of P_Δ can be taken from Sir Andrew Noble's paper, Phil. Trans. A.410, 1906 and extrapolation beyond $\Delta = 0{\cdot}5$ can be effected on the supposition that $\mathrm{P}_\Delta = 125\Delta^{1{\cdot}2}$. The expression, however, does not seem likely to lead to a monomial, but for tubular it becomes

$$\mathrm{P_m}=\mathrm{K\,P}_\Delta\left(\frac{\mathrm{W}}{d^3}\right)\left(\frac{w}{d^3}\right)\left(\frac{d}{l_0}\right)^2$$ leaving K to be determined by experiment.

To determine the value of n in the expression $(\mathrm{P_m})^{3{\cdot}2n}$ by the results of firing there are two ways of setting to work. Series expressly arranged so as to vary w, W, C or l_0 one at a time may be fired, or results from proof rounds fired for other purposes may be used to determine by trial and error the indices for w, W, C and l_0 which give the most constant result for the numerical factor.

It is not to be expected that the same factor will suit all rifled firearms, heavy ordnance, field guns, and small arms, because this same factor is similar in nature to the coefficient of reduction of exterior ballistics, and has to correct not only for those variables which are known to be omitted but also for those other variables which cannot be described even by a name. For instance, it is known that the forcement of the driving band and the friction of the bore are variables, and these are omitted; but it is also known that one maker's powder differs from another in ballistics, although made to the same specification, and the cause of difference is not known. The apparent difference in the behaviour of the same maker's cordite in ordnance and in small arms is discussed in Section VII. In any case whether series expressly arranged are fired, or the results of past proof rounds are used, sets and satisfactory sets of indices for w, W. C and l_0 can be obtained, and from these sets a value of n can be selected, if such a selection is necessary.

SECTION V.

Adjustment of Charbonnier's Formula to correspond with Firing Results.

Working backwards from the firing results of specially arranged series and of ordinary current work for proof of cordite, satisfactory sets of indices have been obtained for several types of gun and explosive and also experimental constants for each set. Provided the type of gun and powder remain the same the experimental constant is equally applicable for any calibre and load. The indices are conveniently shown in tabular form as follows:

Table of Indices for Pressure.

TABLE II.

	w	W	C	l_0	d
Ordnance.					
Tubular nitro-cellulose	+ 1·60	+ 0·60	− 1·10	− 1·40	− 1·90
M.D.T.	+ 1·80	+ 0·68	− 1·00	− 1·40	− 2·80
Cords of M.D. or M^k I.	+ 1·62	+ 0·60	− 1·00 − 1·15*	− 0·85	− 2·81 − 2·36* * M.D.
Small arms with enveloped lead bullets.					
M.D.T. rifle	+ 2·35	+ 0·67	− 1·50	− 1·80	− 2·76
M^k I. cords rifle	+ 2·50	+ 0.70	− 1·60	− 1·60	− 3.20
Other formulas for comparison and remark.					
Sarrau's original	+ 1·50	+ 0·50	− 1·00	− 1·00	− 2·00
Charbonnier's ($n=\frac{1}{2}$)	+ 1.20	+ 0·50	− 0.70	− 1·00	− 2·00
Mr. F. W. Jones's for rifles	+ 1·35	+ 0·50	− 1·00	− 0·55	− 2·00
Anonymous adaptation of Sarrau's	+ 1·69	+ 0·70	− 1·245	− 0·88	− 2·555 − 0·446

In Appendix III, an example is completely worked out for Mark I cordite and ordnance from particulars taken from old official red books on Guns, Ammunition and Explosives, showing how to obtain the numerical value of the constant for this particular powder. One rifle is included to show the difference between ordnance and small arms. The constant is of course dependent upon the accuracy of the details published, and as the size of the cords are taken from "Treatise on Service Explosives", 1907, page 125, column 7, and

differ considerably from the actual dry sizes as measured by the powder makers, the value, log 302·0 = 2·480 should be taken as only academically correct. Persons who possess the real dry diameters will be able to determine from the given sets of indices their own constants for this powder, and for any other powder, such as M. D. Cordite, or Nitro-cellulose. There seems to be no object in publishing such practical details.

Sarrau's original monomial is shown in Table II, for comparison, and also Charbonnier's formula as reduced by me when Sarrau's index $n = \frac{1}{2}$ is used. The difference of 0·30 in the indices of w and C are due to Charbonnier using the initial air volume per lb. and Sarrau the density of loading. Mr. Jones's formula is taken from a valuable article which he contributed to "Arms and Explosives" in February, 1904, entitled "Calculation of Cordite Rifle Ballistics." The anonymous adaptation of Sarrau's formula is one with which I have been familiar for many years, and is the only one in which the index of the calibre contains an unexplained surplus, meaning that in the opinion of the adapter the friction or the loss of heat to the walls or the forcement of the driving band, or some other condition entered into the pressure formula approximately as the square root of the calibre thus giving an extra value of 0·445 to the index of d. I cannot find any justification for the insertion of this arbitrary term. I leave to others the selection of the value of the index n, but the differences in the indices for ordnance and for lead bullets are discussed in Section VII. The initial resistance of the projectile to motion is vastly different. A twelve stone man standing in the base of a 0·303 bullet exerts a forcement equal to about one ton to the square inch of powder gas, and it takes between 850 and 1,000 lbs. dead weight to force the bullet into the rifling.

None of the four formulas quoted for comparison give reliable results over any large range of conditions, and it is especially interesting to calculate pressures of a quantity of rifles with Jones' and Charbonnier's formulas with constants of about log $^{-1}$ 2·49 and 1·59 respectively.

My own indices for rifles are confirmed by experiments devised for the express purpose of ascertaining the percentage change in velocity or pressure caused by a percentage change in the dimensions of the rifle or the charge.

For Mark I cordite, the late Mr. R. H. Housman, B.Sc., M.I.E.E., carried out a long and careful series of experiments for Kynoch's to which firm he belonged until his untimely death in 1905. The actual experimental figures and details were published in the Kynoch Journal, Volumes III, IV, and V, 1902 to 1904, and in that short-lived Journal "Technics" he tried with some success to develop a theory of interior ballistics from the results. Both periodicals can be consulted by anyone in the Library of the Patent Office, Chancery Lane, without any special formality or permission. That the published figures correspond with the instrumental results, and were not adjusted in any way to suit a preconceived theory I can vouch for personally, as I was at one time editor of the Kynoch Journal, and made it my business to check his figures with the proof books.

One series of great value was fired with a 0·450 express rifle with 4 weights of bullets, 800, 640, 480 and 365 grains, and with each bullet the charges of the same batch of government pattern 3¾ cordite were varied by 10 grains at a time to obtain a complete series of pressure from 5 to 30 tons per inch^2. The velocities varied from 1000 f/s to 3000 f/s, and the whole series was carried through with the same rifle, the same cases, the same caps, and the same cordite. The particulars are given in detail in Nos. 19 and 20 of the Kynoch Journal, and in No. 18 there is a detailed table of pressure and velocities for ten different express rifles from 0·577 to 0·303 calibre taken in 30 inch barrels at 60° Fahr. If careful experiment can produce a monomial formula these experiments show that the best one for pressure with cords in rifle firing solid nosed metal covered lead bullets is very nearly as stated in the table, and that the index 1·2 given for w and for l_0 in "The Text Book of Small Arms", 1909, page 203 is not correct for rifles. There may be some small error in my index of w (making it 2·2) in the formula derived from Mr. Housman's results, because the construction of a table of pressure to correspond with the compressions of copper crushers is not a particularly easy business, as he himself showed very clearly in the Kynoch Journal, No. 20, pp. 32 to 34. He took the Woolwich compression for 15 tons per inch^2 as standard, and built up his own table for his side pressure gun by multiplying and dividing the standard by means of several pistons of various diameters acting on similar coppers, and fitted to the same gun, so that the same gas pressure was multiplied or divided according to the area of each piston. The method seems unexceptionable, and gives a ton or two higher pressure at about 30 tons than the statical method, and about the same as the statical method at low pressure, varying slightly from the Woolwich scale throughout except at 15 tons.

It has recently been resuscitated to verify and extend the table for use with lead crushers in shot gun work.

Side pressures are, however, apt to be very unreliable. Unaccountable variations of as much as 20% are by no means rare. "Revue d'artillerie", May 1910, pp. 100-107 in the article "Cartouches à balle pointue en Espagne" gives some facts and figures not readily obtainable by students on this subject.

SECTION VI.

THE FORMATION OF A VELOCITY MONOMIAL.

Having obtained independent expressions for the maximum pressure in terms of the dimensions of the gun and charge, the next step is to substitute them in the expression given in Section III, by summing the indices there given and half the indices of the ordnance pressures, neglecting the constants altogether. The results for M.D. are as follows:—

TABLE III.

	w	W	C	l_0	u	d
For tubes—						
From V. forumla	− 0·05	− 0·75	+ 0·18	+ 0·50	+ 0·12	+ 1·24
by half P_m	+ 0·75	+ 0·30	— 0·25	— 0·90	0	— 1·50
Sum	+ 0·70	- 0·45	− 0·07	− 0·40	+ 0·12	— 0·26
For cords—						
From V. formula	− 0·08	− 0·67	+ 0·29	+ 0·35	+ 0·12	+ 0·94
by half P_m	+ 0·81	+ 0·30	− 0·50	− 0·43	0	− 1·40
Sum	+ 0·73	− 0·37	− 0·22	− 0·08	+ 0·12	− 0·46

It will be noticed that the indices of C and l_0 in the sum have each one nearly vanishing value which is contrary to all experience, and indicates that the velocity formula derived from Ingalls' method is in need of a correcting factor. This factor would seem to be his v_c, which is taken to be constant, although experience has shown it to be a variable, in the sense that it has to correct for all erroneous assumptions, and consequently it has always been a difficult characteristic to estimate when designing a charge by his method.

The two sets of indices just found may well be expected to serve as a first approximation to the correct sets, and by a similar method to that used for the pressure formula better sets can be found by trial and error. Appendix III contains a scheme of computation for verifying the indices, and for determining the numerical constant for any powder, and for any shape. Two constants are shown in it for the two values of the index of the charge w, 0·60 and 0·65. The former is nearer to the average value with cords. The latter has been put in as a smoothing figure to correct for the known irregularities in the data and especially to show the effect on the constant of altering an index. As in the pressure formulas five sets of indices have been found, and they are as follows:—

TABLE OF INDICES FOR VELOCITY.

TABLE IV.

	w	W	C	l_0	u	d
Ordnance.						
Nitro-cellulose tubular	+ 0·65	− 0·30	− 0·25	− 0·30	+ 0·12	− 0·12
M.D.T.	+ 0·70	− 0.30	− 0‘25	− 0·30	+ 0·12	− 0·27
M.D. or M^k I. cords.	+ 0·60	− 0·30	− 0·25	− 0·15	+ 0·12	− 0·12
Small arms with enveloped lead bullets.						
M.D.T.	+ 1·00	*− 0.20	− 0·50	− 0·67	+ 0.12	− 0·35
M^k I. size 3¾	+ 1·00	−03.2	− 0·37	− 0·50	+ 0·12	− 0·55
Monomials quoted by Ingalls from Sarrau.						
Sarrau's for slow burning powder	+ 5/8	− 7/16	− ¼	− ¼	+ 3/16	- 1/8
Glennon's for quick burning powder	+ 5/8	− ½	− ¼	− 0	+ 1/8	− ¼

* I should have expected this to be 0·3, but 0·2 was the result of careful experiment varying only the bullet.

The small arm formula for cords is particularly interesting because it gives practically the same results as the formula given by Mr. Jones in his article already mentioned. Incidentally, it differs from the Text Book of Small Arms, page 203. Mr. Jones' formula in his own symbols is:—

$$V = 2380\ (P_m)^{0\cdot37} \sqrt{\frac{C}{W + 400d}}$$

Where C is the weight of the charge, and W of the shot, both in grains, the other symbols having their usual meanings.

His pressure formula for substitution is :—

$$P_m = \frac{\Delta C^{0\cdot35}\ W^{0\cdot5}}{20d^2}$$

where Δ is the density of loading, taken by him from the air space in the unfired cartridge, without allowance for the free travel. It is well known that his velocity formula gives most reliable results, but that his pressure formula breaks down occasionally, and this

latter might be expected from his indices. He himself does not appear to have noticed that his empirical velocity formula can be made to contain all the usual variables present in similar formulas derived from theoretical considerations as he says it should. Recasting it by substitutions it can be so written and then it is seen to be identical with my new monomial.

His pressure formula can be written in my symbols:

$$P_m = K\left(\frac{w}{d^3}\right)^{1\cdot35}\left(\frac{W}{d^3}\right)^{0\cdot5}\left(\frac{d^3}{C}\right)^{1\cdot0}\left(\frac{d}{l_0}\right)^{0\cdot55}$$

by putting Δ in terms of w and C and giving to his unbalanced $d^{0\cdot55}$ the denominator l_0 which is a constant for his rifles, being all loaded with size 3¾. $(P_m)^{0\cdot37}$ can now be put monomially into the velocity formula.

The term $w + 400d$ can also be written monomially by noticing that the length of all express rifle bullets is about the same, or say one and a quarter inches, making the sectional density constant or $w/d^2 = \frac{1}{3}$ nearly.

Then by using logarithmic paper and plotting his values of $\frac{w + 400d}{d^3}$ it is seen that the expression

$$\left(\frac{W}{d^3} \times \frac{1\cdot1}{d^{\frac{1}{3}}}\right)^{\frac{1}{2}}$$

with W in lbs. can be used instead of the binomial. The unbalanced index of d is now ½ of ⅓, or 0·17, which has to be shared between the thickness of the cord l_0, and the travel of the shot u, the two variables omitted as constants, the length of the barrel being taken as 30 inches. The index of u is known to be + 0·12, so that the index of l_0 must be 0·29 to complete the total of 0·17, taking regard of the signs.

Collecting the indices as follows:—

	$\frac{w}{d^3}$	$\frac{W}{d^3}$	$\frac{C}{d^3}$	$\frac{l_0}{d}$	$\frac{12u}{d}$
from $(P_m)^{0\cdot37}$	+ 0·5	+ 0·185	− 0·37	− 0·2035	0
from beneath the root	+ 0·5	− 0·500	0	− 0·29	+ 0·12
approx sum	+ 1·00	− 0·32	− 0·37	− 0.50	+ 0·12

and comparing the result with my monomial the two are identical, although obtained by widely different methods.

In the Kynoch Journal, January 1904, No. 25, in an article entitled "Facts versus Formulae" the late Mr. Housman severely criticised Mr. Jones's formula, and now it happens that the results given by the offending formula are being used equally with Mr. Housman's facts for a constructive purpose. Neither of the experts

of the great firms of Eley or Kynoch were likely to be far wrong in the design of express rifle cartridge, although their methods of expressing their results put them into apparent contradiction. This analysis is not intended as an adverse criticism of either, for without their work and formulas before me I should never have had the courage to try every combination of indices, in the sure hope of eventually succeeding in obtaining satisfactory results. The formula for velocity quoted from my writings by the Text Book of Small Arms p. 204 was actually derived from Mr. Jones' formula.

(To be continued).

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APPENDIX I.

Symbols and their meaning.

The bar above a symbol (thus :— $\overline{X}$) refers to the particular value of that symbol at the instant when the burning of the powder is completed (Lissak p. 84).

Symbol.	Reference.	Meaning.
a^2 ...	$\frac{1}{\Delta} - \frac{1}{\delta}$	δ being 1·57, a^2 is tabulated against Δ in Table 1. The initial air space per lb.
C ...	... ...	Volume of chamber in cubic inches.
d ...	... ...	Calibre in inches.
f ...	Force	See List of Formulas (Chemical).
l ...	See equation (22)	Thickness (inches) of layer burnt at any instant.
l_o ...	... ...	Half least dimension of grain of powder, inches.
M ...	See equation (14)	Ballistic velocity constant, f/s
M′ ...	,, ,, (16)	Ballistic pressure constant, tons/in^2.
N ...	,, ,, (15)	A ballistic constant.
P′ ...	,, ,, (21)	Closed vessel pressure tons/in^2 at density of loading, or a ballistic pressure constant.
P ...	,, ,, (13_a)	Pressure while powder burns, tons/in^2.
P_a ...	,, ,, (20)	Pressure after powder is burnt, tons/in^2.
P_m ...	,, ,, (6), (7), (8) ...	Maximum pressure, tons/in^2.
u ...	... ...	Travel of shot after any given time, feet.
u_o ...	... ...	Length of rifled portion, feet.
v ...	See equation (13)	Velocity of shot while powder burns f/s.
v_a ...	,, ,, (19)	Velocity of shot after powder is burnt, f/s.
V ...	,, ,, (11)	Muzzle velocity, f/s.
V_1 ...	,, ,, (12)	Velocity after infinite travel, when P_a = atmosphere.
v_c ...	,, ,, (18)	Velocity of combustion of powder at atmospheric pressure, in/sec.
W ...	... ...	Weight of shot, lbs.
w ...	... ...	Weight of powder, lbs.
x ...	... ...	Number of expansions of initial air space.
x_o ...	See equation (4)	As for x, but refers to muzzle distance.
$X_o \ldots X_5$	See equations (24) to (31) . .	Functions of x.
$\overline{X}_o$ ...	See equation (9), (10) ...	Value of X_o at instant powder is consumed.
y ...	,, ,, (23)	Weight of powder burnt at any instant, lbs.
α, λ, μ ...	... ...	Constants relating to shape of grain.
δ ...	See equation (2)	Specific gravity (mean) of modern colloid powders, i.e., 1·57.
Δ ...	,, ,, (1)	Density of loading.

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APPENDIX II.

X	$f(\Sigma)$,	(cords) diff.	(tubes) X_0	(tubes) diff.	X_2	diff.
1	3·07		3·19		0·206	
		14		108		101
2	3·21		4·27		0·307	
		40		75		63
3	3.61		5·02		0·370	
		24		58		45
4	3.85		5·60		0·415	
		22		49		35
5	4.07		6·09		0.450	
		20		42		27
6	4·27		6·51		0·477	
		16		38		23
7	4·43		6·89		0·500	
		16		33		19
8	4·59		7·22		0·519	
		14		31		17
9	4·73		7·53		0·536	
		12		28		14
10	4·85		7·81		0·550	
		12		26		13
11	4.97		8·07		0·563	
		12		25		12
12	5·09		8·32		0·575	
		11		23		10
13	5·20		8·55		0·585	
		10		22		10
14	5·30		8.77		0·595	
		10		21		8
15	5·40		8·98		0·603	
		10		20		8
16	5·50		9·18		0·611	
		10		19		7
17	5·60		9·37		0.618	
		9		18		7
18	5.69		9.55		0.625	
		8		17		7
19	5·77		9·72		0·632	
		8		17		6
20	5·85		9·89		0·638	
		8		16		5
21	5·93		10·05		0·643	
		7		16		5
22	6·00		10·21		0.648	
		7		15		5
23	6·07		10·36		0·653	
		7		15		5
24	6·14		10·51		0·658	
		7		14		5
25	6·21		10.65		0.663	
29·42	6·5		11·24			
		50		103		
38·67	7·0		12·27			
		50		101		
49·44	7·5		13·28			
		50		101		
62·27	8·0		14·29			
		200		405		
138·87	10·0		18·34			

Δ	a^2	$\frac{1}{5}$ diff.
0·20	4·36	
		20
0·25	3.36	
		13
0·3	2·70	
		10
0·35	2·22	
		7
0·4	1·86	
		5
0,45	1·59	
		4
0·5	1·36	
		4
0·55	1·18	
		3
0·6	1·03	
		2
0·65	0·90	
		2
0·7	0·79	
		2
0·75	0·69	
		2
0·8	0·61	
		2
0.85	0.54	

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APPENDIX III.

Particulars of some Guns and Charges. Cordite Mark I. Taken from published books.

	Gun Mark	12″ B.L. VIII.	9·2″ B.L. VIII.	6″ Q.F. I.	4·7″ Q.F. I.	4″ Q.F. I.	12-pr. 12 cwt. Q.F. I.	5″ B.L. III.	12-pr. B.L. I.	6″ B.L. How. 30 cwt.	5″ B.L. How. I.	·303 rifle. II.
Calibre (inch)		12·0	9·2	6·0	4·7	4·0	3·0	5·0	3·0	6·0	5·0	0·307
Shot (lbs.)		850	380	100	45	25	12·5	50	12·5	118·5	50	0·0307
Charge (lbs.)		167·5	63·0	13·25	5·44	3·56	1·94	4·45	1·0	1·81	0·715	0·0045
Chamber (cub. ins.)		13,400	4,600	730	298	220	125	504	115	229	75	0·210
Diameter of cordite (inch)		0·490	0·348	0·263	0·180	0·136	0·136	0·063	0·044	0·044	0·032	0·032
Shot travel (in.)		349	316	215	171	143	103	104	73	75	36·8	23
Pressure (tons per inch²)		16·5	17·0	15·5	15·0	14·5	14·0	15·0	15·0	10?	9?	15·0
Velocity f.s.		2375	2360	2200	2185	2320	2225	1770	1680	780	770	2030
d^3/W		2·03	2·05	2·16	2·31	2·56	2·16	2·50	2·16	1·82	2·50	0·942
d^3/w		10·3	12·4	16·3	19·1	18·0	13·9	28·1	27·0	119·0	175·0	6·42
C/d^3		7·75	5·91	3·38	2·87	3·44	4·63	4·03	4·26	1·06	0·60	7·27
d/lo		49·0	52·9	45·6	52·1	58·8	44·1	159·0	136·0	273·0	313·0	19·2
12 u/d		29·5	34·4	36·0	36·7	36·0	35·0	21·0	24·0	12·5	7·3	91·0
log d^3/W		0·308	0·312	0·335	0·364	0·408	0·335	0·398	0·335	0·260	0·398	$\bar{1}$·974
log d^3/w		1·013	1·093	1·212	1·281	1·255	1·143	1·449	1·431	2·076	2·243	0·808
log C/d^3		0·889	0·772	0·529	0·458	0·537	0·666	0·605	0·629	0·025	$\bar{1}$·778	0·862
log d/lo		1·690	1·724	1·629	1·717	1·769	1·644	2·201	2·134	2·436	2·496	1·283
log 12 u/d		1·470	1·537	1·556	1·565	1·556	1·544	1·322	1·380	1·097	0·863	1·959
Calculation of Pressure Constant.												
Log P_m		1·218	1·230	1·190	1·176	1·161	1·146	1·176	1·146	1·000	0·954	1·176
1·0 log C/d^3		0·889	0·772	0·529	0·458	0·537	0·666	0·605	0·629	0·025	$\bar{1}$·778	0·862
1·62 log d^3/w		1·640	1·770	1·964	2·078	2·035	1·850	2·347	2·320	3·362	3·637	1·310
0·6 log d^3/W		0·185	0·187	0·201	0·218	0·245	0·201	0·239	0·201	0·156	0·239	$\bar{1}$·984
Sum = A		3·932	3·959	3·884	3·930	3·978	3·863	3·367	3·296	3·543	3·608	3·332
0·85 log d/lo		1·438	1·467	1·408	1·458	1·506	1·397	1·870	1·813	2·071	2·121	1·092
A – ditto. = log K_1		2·494	2·492	2·476	2·472	2·475	2·466	2·497	2·483	2·472	2·487	2·240
Calculation of velocity constant, and showing the effect of changing an index.												
log V		3·375	3·373	3·342	3·340	3·366	3·347	3·248	3·225	2·892	2·887	3·308
0·6 log d^3/w		0·606	0·656	0·727	0·766	0·753	0·684	0·870	0·858	1·245	1·347	0·485
0·25 log C/d^3		0·222	0·193	0·132	0·114	0·134	0·166	0·151	0·157	0·006	$\bar{1}$·944	0·202
Sum = A		4·203	4·222	4·201	4·222	4·253	4·197	4·269	4·240	4·143	4·178	3·995
0·44 log d^3/W		0·135	0·137	0·147	0·160	0·179	0·147	0·175	0·147	0·114	0·175	$\bar{1}$·988
0·15 log d/lo		0·254	0·258	0·249	0·258	0·265	0·247	0·330	0·320	0·365	0·374	0·193
0·12 log 12 u/d		0·176	0·184	0·187	0·188	0·187	0·186	0·159	0·166	0·132	0·104	0·235
Sum = B		0·565	0·579	0·583	0·606	0·631	0·580	0·664	0·633	0·611	0·653	0·416
A – B = log K_2		3·638	3·643	3·618	3·616	3·622	3·617	3·605	3·607	3·532	2·525	3·579
Log K_2 + 0·05 log d^3/w		3·688	3·697	3·678	3·680	3·685	3·674	3·677	3·678	3·3635	3·637	3·619

THE OBSERVER'S RULE OF THUMB.

BY CAPTAIN D. G. T. SNEYD, R.G.A.

AS the "splash" of the bullets from a Time Shrapnel "air" burst is frequently missed it is useful to have some simple rule of thumb for calculating the distance of the mean point of impact from the target. Assuming the Battery line of fire to be approximately correct, this can be done if we know:—

(a). The distance of the burst from the target on the line BT. for a burst observed at O as 1° off the observer's line OE and

(*b*). The distance ahead of the burst of the mean point of impact for a burst observed at O as 1° high.

To find (a):—

Up to an apex angle OTB of 60°. Divide the observer's range OT by the apex angle. If OTB be greater than 60, divide OT by 60.

To find (b):—

Divide the observer's range OT by the angle of descent.

Bursts observed at angles other than 1° will of course be at proportionate distances.

Explanation.

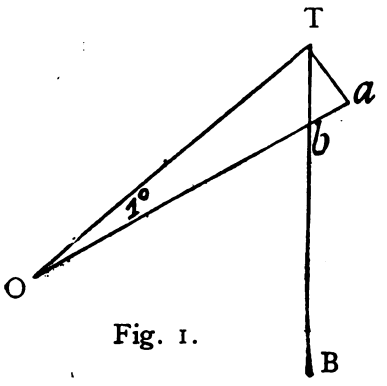

Fig. 1.

In Fig. 1 let:—
O = Observer,
T = Target,
B = Battery.

Draw T*a* at right angles to OT and make TO*a* = 1°. Then the distance T*b* will be the amount on BT subtended by 1° at O.

To find T*a*:—

As $\tan 1^\circ = \frac{1}{57{\cdot}3}$ $\therefore$ $Ta = \frac{OT}{57{\cdot}3}$

This amount we will call Z.

For all practical purposes T*ab* can be treated as a right angle and therefore T*ba* as equal to OTB, the apex angle.

$$\frac{Tb}{Ta} = \text{cosec } Tba \text{ i.e. cosec OTB but } Ta = Z$$

$$\therefore Tb = Z \text{ cosec OTB}$$

We now want to find the distance of the mean point of compact ahead of a burst observed as 1° high from O.

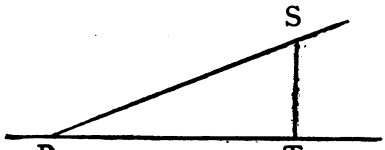

Fig. 2.

In Fig. 2 which shows the points in a vertical plane let:—
S = point of burst 1° above Target T, and let SPT = angle of descent. Then PT will be the distance ahead of the burst of the mean point of impact.

Now $\frac{PT}{ST}$ = cot SPT but ST subtends 1° at O and this amount we have already discovered and called Z.

$\therefore$ PT = Z cot angle of descent.

Example:—

Observer on the left of B.T.
Observer's range OT = 3000
Apex angle OTB = 50°
Angle of descent = 15°

Round.	Amount off observer's line = OT.	Distance of burst from Target on line BT.	Height of burst as observed at O.	Distance ahead of burst = of mean point of impact.	Result.
1	1° Left	+ 60	1° High	+ 200	+ 260
2	1° 30′ Right	− 90	30′ High	+ 100	+ 10
3	2° 30′ Right	− 150	45′ High	+ 150	Range

The exact method.

For those who prefer methods which are more exact and save subsequent calculations, the following procedure can be adopted.

Divide OT by 57·3 and call this amount Z.

To find (a):—

Multiply cosec OTB by Z

To find (b):—

Multiply cot angle of descent by Z

For preference use two slide rules, one for each factor. Then by placing 60 on the slider under the results obtained above, the slide rules will be so set that the distances required can be immediately read on the rule, above the angular distances in minutes reported by the Observer.

PLANE-TABLE TRIANGULATION FROM ONE STATION ONLY.

By E. A. Reeves, Esq.

(Map Curator and Instructor in Surveying, Royal Geographical Society).

(From 'The Geographical Journal' for May, 1915). With additions and alterations.

THE following is a short description of an attachment I have recently fitted to a plane-table alidade for rapid graphic triangulation and fixing the distance of points from one station only, with an example of work done.

Let 1, 2, 3, 4 (Fig. 1) be a plane-table over a station at A; B and C, distant points in the country, of which B is much nearer to A than C. To determine the distance of the point C by ordinary methods of plane-tabling, the distance from A to B is measured on the ground and set off to scale on the plane-table, on which it is represented by A*b*. AB now serves as a base, and after drawing rays from A towards B and C, the surveyor moves his plane-table to B, orients, and again draws a ray towards C, the intersection of which ray with that drawn towards the same point from A gives the position and distance of C. *c* represents this point on the plane-table.

However, in order to carry out this operation it is necessary for the surveyor to move his plane-table from one end of the base to the other; and if a distant point such as C could be fixed and a graphic triangulation carried out from one station only, without moving the plane-table, it would frequently be a great advantage, especially in country difficult for travelling.

The attachment here described provides means of doing this; and it is not

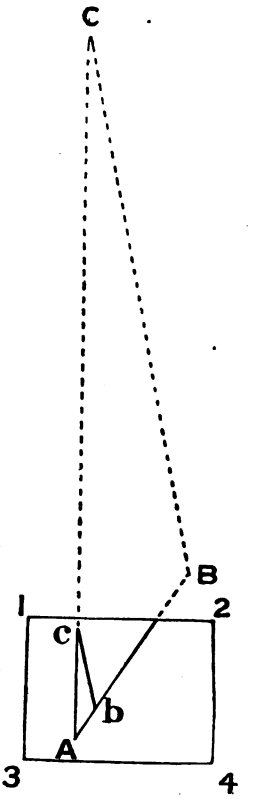

Fig. 1.

limited to short distances as is the case with ordinary tacheometers and range-finders, but can be used for distances of 5 or 10 miles, or even greater if the points are clearly visible, and the operation is carefully carried out with suitable triangles and altitudes as explained later.

When fixed points have been previously laid down on the plane-table sheet, one of these can be selected, as B, and its distance from A, the surveyor's position, taken from the scale; but when no previously fixed points are available, the distance AB which is to serve as a base can be obtained directly by the distance-finder alidade or any other suitable instrument, and then the problem will be solved if from *b* on the plane-table the line *bc* can be drawn parallel with BC in nature, while the surveyor is still stationed at A.

To enable this to be done, the telescope of a plane-table alidade (see Fig. 6), with an arc to measure vertical angles, has been fitted

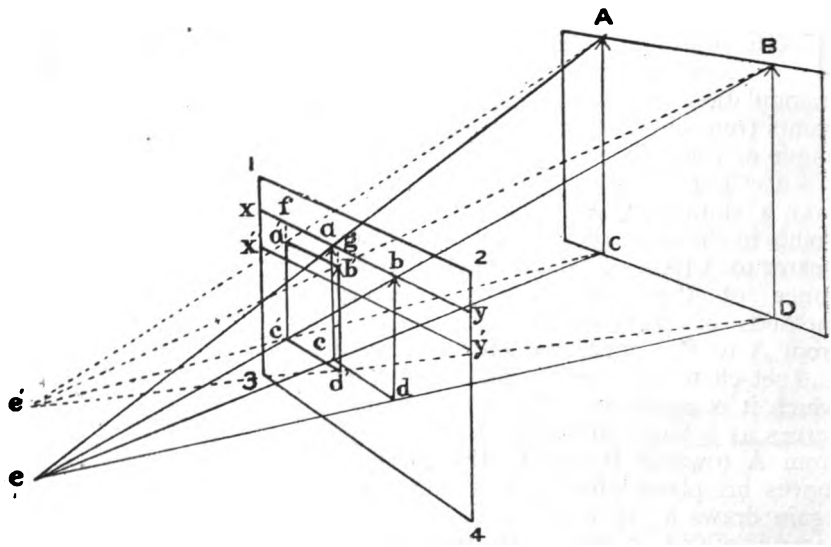

Fig. 2.

with a long light frame carrying two, three or any suitable number of horizontal wires, all parallel with one another, parallel with the optical axis of the telescope and with the fiducial edge of the alidade when the instrument is levelled and pointing in the direction of the horizon line.

If now the vertical angle that one of the objects subtends from the other, as C from B (Fig. 1), is set on the arc, and the alidade, kept truly level, is placed over the point *b* on the plane-table, and turned round horizontally until the tops of the two distant points B and C are seen with one eye (the other being closed) to coincide exactly with any of the long horizontal wires, and both to lie in a line parallel with those wires in the spaces between them or above them as the eye is moved up and down, the alidade must be parallel with the

line joining the two distant points B and C in nature, and a line *bc* drawn on the plane-table will represent the same line that would be drawn if the plane-table had been carried to B, the other end of the base AB, and the intersection of C made from there in the ordinary manner. This can be proved as follows:—

Let 1, 2, 3, 4 (Fig. 2) be a transparent vertical plane, with cross-wires *xy*, *x'y'*, etc., and suppose this plane placed so that these wires are exactly parallel with the line joining two distant points, shown by AB. Now supposing the eye at *e*, AB will be represented by *ab* on the wire *xy*, so long as the plane 1, 2, 3, 4 is parallel with the plane passing through the points A, B, and in the right-angled triangles A*e*C, *aec*, and B*e*D, *bed*.

$$ac : AC :: bd : BD$$

and

$$ae : Ae :: be : Be$$

since the line *ab* joining the two points is parallel with AB, and the points are on the same wire *xy*. When the eye is moved to another

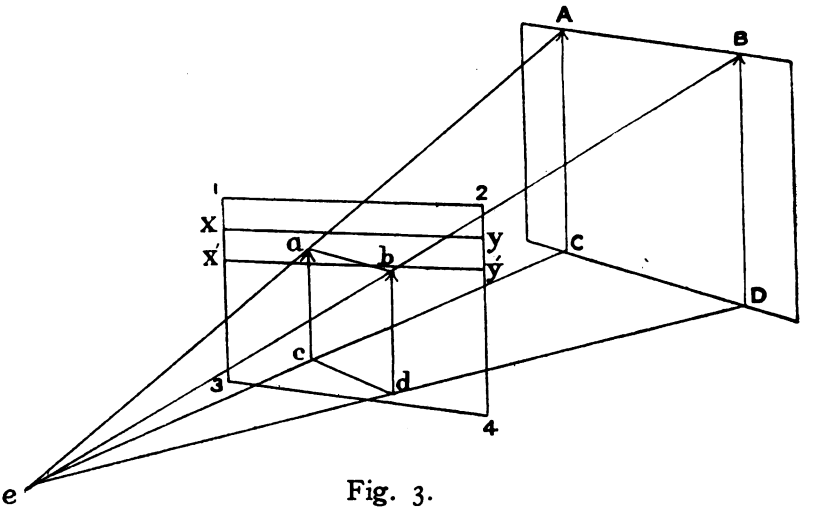

Fig. 3.

position, as *e'*, the points A, B will be represented by points in a line parallel with *a*, *b*, since the proportions hold good as before. In this case they will be at *a'*, *b'* below the wire *xy*, and $\frac{fc'}{fa'} = \frac{gd'}{gb'}$. Therefore, if the wires *xy*, *x'y'*, etc., are exactly parallel with the plane in which the points A, B are situated, the points *a*, *b* representing these points will be always either both on one of the wires or both in a line parallel with these wires in one of the spaces between them. But unless this parallelism holds good this cannot be the case, as the proportion ceases to exist; consequently, the line *ab*, representing that joining the distant points AB, will be seen to intersect the horizontal wires (see Fig. 3), instead of to run parallel with them.

The vertical angle that one distant point subtends from another, such as C from B (Fig. 1), which it is necessary to set on the arc of the alidade, can be obtained with sufficient accuracy for the purpose from the distance of the near point B, the assumed distance of the further point C, and the vertical angle of each of these points as measured on the arc of the alidade from the surveyor's position, A. The assumed distance of C may be as much as twenty per cent. or more in error if the proper conditions are carried out as regards size of angles and length of sides of the triangle.

With the required vertical angle set on the arc, the position of the distant point C can be found by intersection as previously described. If this position differs widely from that previously assumed the work should be repeated, using the new distance of C in the computation of the vertical angle.

The formula for computing the vertical angle of C from B is very simple, and can be worked out in the field in about two or three minutes. It is as follows (Fig. 1):—

$$\left.\begin{matrix}\text{Required} \\ \text{vertical angle}\end{matrix}\right\} = \frac{(\text{dist. A}c \times \text{vert. angle C}) - (\text{dist. A}b \times \text{vert. angle B})}{\text{dist. } bc}$$

The distances may be measured on the plane-table by means of a scale of inches and decimals.

When the vertical angle of the distant point C, as measured at A, is over 10 or 12 degrees, the distances A*c* and A*b* in the formula should be multiplied by the tangents of the vertical angles of B and C, instead of by the angles themselves, and the difference between the products divided by *bc* is the tangent of the required angle. As will be seen from the following example worked both ways, the difference in the results is small unless the angles are large:

Vertical angle of C = 10°, tan 0·1763

" " B = 1°, tan 0·0175

$$\frac{(9 \times 10^\circ) - (1{\cdot}7 \times 1^\circ)}{7{\cdot}5} = 11^\circ{\cdot}77 \text{ (or } 11^\circ 46')$$

$$\frac{(9 \times \tan 10^\circ) - (1{\cdot}7 \times \tan 1^\circ)}{7{\cdot}5} = \tan 0{\cdot}2076 \ (= 11^\circ 44')$$

Care must be taken to give the proper sign to the vertical angles measured at A, *i.e.* elevation is + and depression −, and it must be remembered that it is the algebraical difference between the two distances multiplied by the vertical angles that it required, so that the sign of the second term of the upper line in the formula must be changed according to the ordinary rule for algebraical differences.

In order that the assumed distance of the point C from A may be sufficiently accurate, even if considerably in error, it is necessary that the side AC and BC should be at least four or five times as long as the base AB. In every case the product A*c* × vertical angle C should be not less than eight or nine times the product A*b* × vertical angle B, and greater than this if possible. The vertical angle of B

should be as near 0° as possible, and should never exceed 1° but the vertical angle of the distant point C may be any magnitude provided it is not less than about 2 or 3 degrees. The position of B should be so selected that its distance from C does not differ greatly from the distance of A from C (see Fig. 4.).

It is important to bear in mind that the angle that C subtends from B, which has to be set on the arc, should be as large as possible so as to give a good inclination to the wire attachment, and that the method fails altogether when this angle is 0°.

The estimated distance should not be unreasonably wrong. If it is not known at all, an approximate distance can be obtained by drawing a line on the plane-table sheet from *b* roughly parallel with the line joining CB in nature. A pencil or ruler held in the line as near as it is possible to judge it will assist.

When suitable distances and altitudes are selected and the triangle is favourable in form, quite a large error in the assumed distance AC causes little error in the vertical angle of C from B, which is to be set on the arc. This will be clear from the following example (Fig. 4), in which an error in the assumed distance of about 30 per. cent. makes no difference in the angle for the first two decimals of a degree.

Vertical angle of C = 8°
" " B = 0·9°

Case 1.

$$\frac{(10{\cdot}2 \times 8^\circ) - (2 \times 0{\cdot}9^\circ)}{10} = 7^\circ{\cdot}98 \text{ (or } 7^\circ\ 58{\cdot}8')$$

Case 2.

$$\frac{(13{\cdot}2 \times 8^\circ) - (2 \times 0{\cdot}9^\circ)}{13} = 7^\circ{\cdot}98 \text{ (or } 7^\circ 58{\cdot}8')$$

It will be evident on considering this formula that if *bc* (Fig. 1) were exactly the same length as A*c* and the point B at the same altitude as A so that its verticle angle = 0°, the formula would be:

$$\left.\begin{matrix}\text{Vert. angle} \\ \text{of C from B}\end{matrix}\right\} = \frac{(\text{Dist. A}c \times \text{vert. angle C}) - (0^\circ)}{bc\ (=\text{A}c)}$$

C would subtend the same angle at B that it does at A, and the correct angle would be obtained whatever the distance A*c* is assumed to be. However, since the angle CAB is supposed to be constant this is never quite possible, but the nearer this condition is reached the better, and the greater the permissible error in the estimated distance AC.

If the angle B had been a depression, case 1 in the example just given would have been:—

$$\frac{(10{\cdot}2 \times 8) - (2 \times -0{\cdot}9^\circ)}{10} = 8{\cdot}34^\circ \text{ (or } 8^\circ{\cdot}20{\cdot}4')$$

Another method of finding the vertical angle to set on the arc is by means of a tangent scale, carefully constructed, and ruled into degrees. The operation is very rapid, but not so accurate as that already given. With a pair of dividers, the distances A*c* and A*b*, taken directly from the plane-table, are set off on the lower line 1-2; let 1-3 and 1-4 represent these distances (Fig. 5). A mark at right angles to these points is made at the respective vertical angles previously measured. Let 3` and 4` be these marks. Then the difference between the perpendicular lines 3-3` and 4-4` will be approximately the tangent of the vertical angle that the distant point C subtends from B. This difference, shown by 5-6, taken in the dividers, and set up vertically at the distance of C from B measured on the plane-table, shown by 1-6 (Fig. 5), will be the tangent of the angle required to be set on the arc of the alidade. If one measured angle is an elevation and the other depression, the difference to be used as the tangent of the required angle is the total length of the two, or, correctly speaking, it is the algebraical difference.

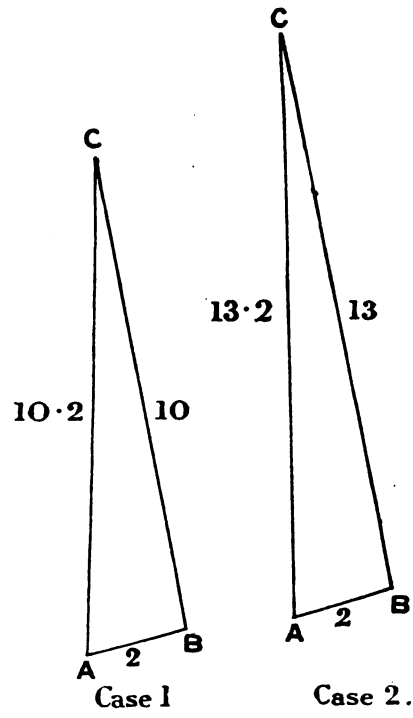

Fig. 4.

It frequently happens that maps can be obtained on which definite points are already laid down, in which case this instrument can be used for fixing other points on the map without having first to measure a base with the distance-finder. The operation is as follows: Accurately level the plane table, orient it, and fix the position occupied by resection, by one of the ordinary methods. Select as B, a comparatively near visible point given on the map, on or near the same side of the plane-table as the point C to be fixed, so as to form a suitable triangle for the work; rule a line in the direction of this latter, and set on the vertical angle that one point subtends from the other, found either by the formula given, or the tangent scale. Place the alidade on the known point, *b*, on the plane-table, and proceed to set it parallel with BC, and make the intersection, as previously described.

Having fixed one point, others can be very rapidly determined from this, provided suitable triangles and vertical angles are selected.

In making the alignment, it frequently happens that the eye has

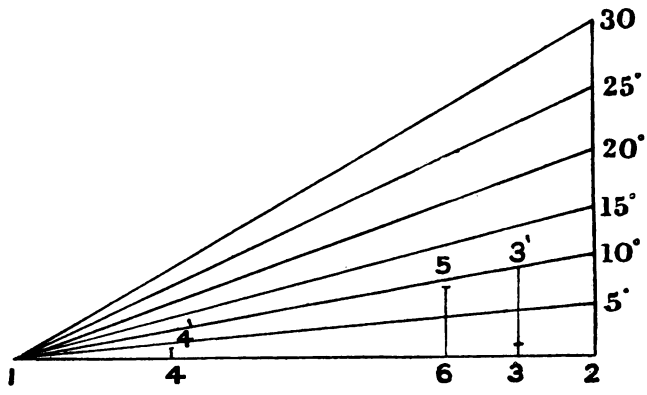

Fig. 5.

to be placed so close to the wires that they tend to become blurred and indistinct; but this difficulty can be overcome by cutting a narrow slot in a piece of cardboard, and sighting the wires through this slot.

It is most important that the instrument should be in proper adjustment so that the angles measured are the true angles of elevation and depression, and that the wire attachment is truly horizontal when the arc is set at 0° and the alidade levelled. Means should be provided for testing these adjustments. The angles could be verified much in the same way that the vertical angles of a theodolite are tested by readings on opposite faces, or 'face left' and 'face right.' For this a complete altitude circle would be required instead of the section of a circle shown in Fig. 6. It would also be necessary to see that the telescope and wire attachment can be reversed, the wire attachment can be tested when the vertical angle readings and level have been adjusted, as follows: compute the true vertical angle subtended by two known points (as C from B Fig. 4) from their true distances and correctly measured vertical angles; set this angle on the arc and place the alidade on the points B.C. If the wire attachment is in adjustment B.C. will appear to coincide exactly with the wires, if they do not the attachment itself must be set so that they do by suitable adjusting screws.

The distance obtained by this instrument multiplied by the tangent of the vertical angle (already measured) gives the difference of height between the surveyor's position and the point observed, so that approximate contours can be sketched in, and the general topographical features drawn on the map, from the one station A only. For distances greater than 5 miles these heights should be corrected for curvature and refraction.

As regards the accuracy attainable in the plane-table intersections, too much must not be expected of this or any other graphic method; but from work already done with the in-

strument it is clear that quite useful results are possible if proper precautions are taken. The board must, of course, be accurately levelled, and every care should be taken to ensure a true parallelism in the alignment of the two points in the country with the wires and spaces between the wires. Practice has shown that this can be done with greater accuracy than might at first be expected, especially when means of several fixings are taken.

Referring to Fig. 1, suppose the alidade with the wire attachment placed over *b*. Then when the point B is seen at the end near the eye, the distant point C will, owing to the foreshortening, be near the farther end of the wires. Now, if at this farther end so large an error as 0·5 inch be supposed in turning the alidade laterally to bring it into a line parallel with the distant points, since the wires are about 30 inches long, this would only cause an error in the intersection of a ray 3 inches in length of 0·05 inch.

It is, of course, not intended that this attachment should be used

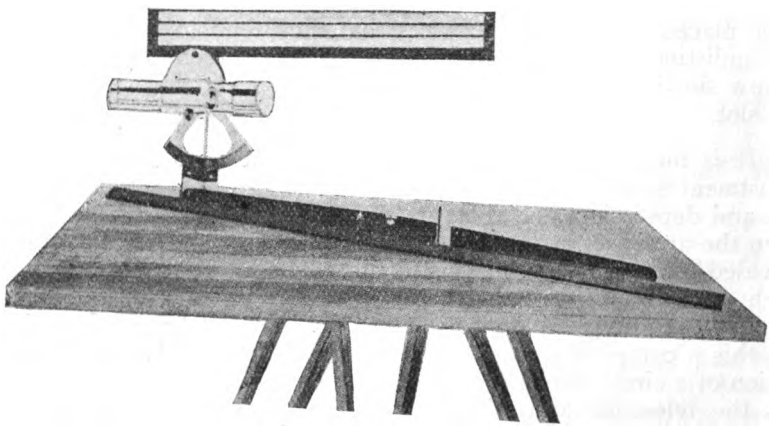

Fig. 6.
Plane-table alidade fitted with the new attachment.

when points can be conveniently fixed by ordinary methods; but it will enable a plane-tabler to do what hitherto he has had no means of doing, that is, fix with fair accuracy, the position of points miles away, from one station only, without moving the plane-table. In rough and difficult country it is hoped, therefore, that it may prove of service.

Fig. 6 shows a telescopic alidade fitted with this new attachment, and Fig. 7 is an example of the fixing of two points from the top of Redhill Common by means of this instrument. The one with the greater distance (Outwood windmill) is about 4·3 miles off. The results as tested by the distances taken from the Ordnance map are quite as satisfactory as could be expected, considering that the work was done on a very misty and wet day. The error for the distance of 7580 yards is about 45 yards, or 0·6 per cent., and this after a second extension.

With AB as known distance, previously found with Distance Finder, the distance of C was obtained. Then from C the graphic triangulation was extended to D. The error in the distance AD. 7580 yards is 45 yards, about 0·6 per cent of the whole as checked by the 6in Ordnance map. From D the triangulation could have been again extended to points three or four times as far, but for mist that made it impossible to see further.

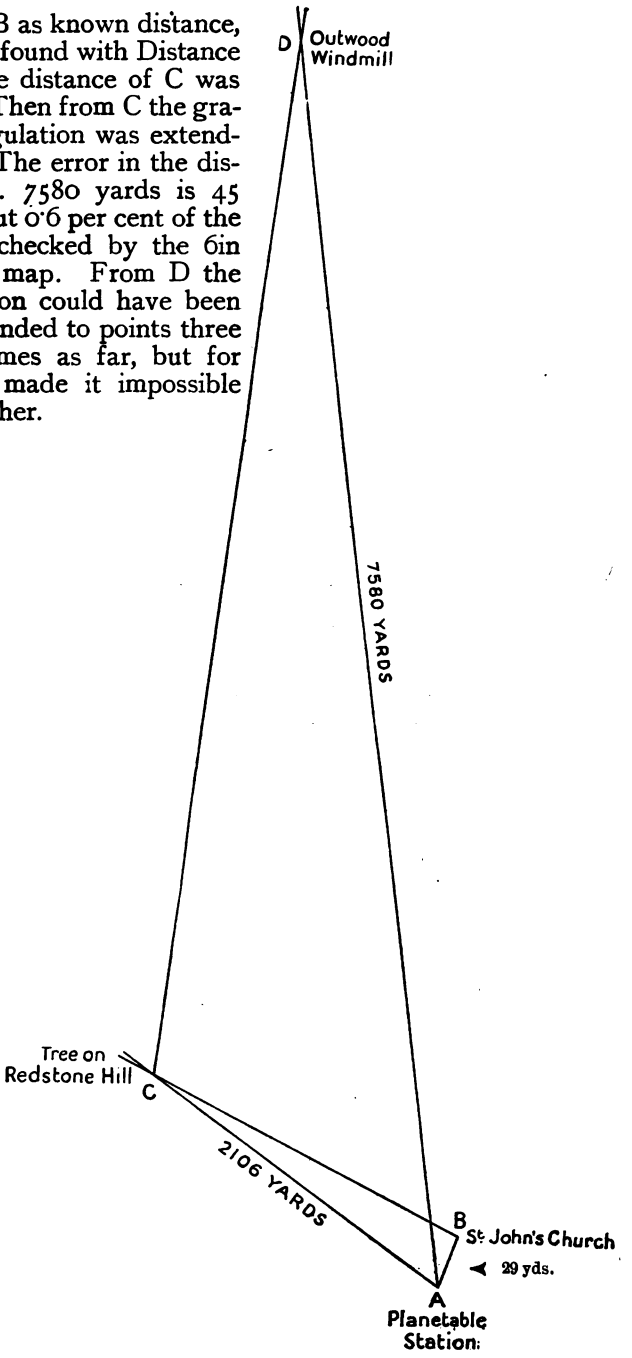

Fig. 7.
Specimen of work done with the new attachment to Plane-Table Alidade.

It is not absolutely necessary that a telescopic alidade should be used for this attachment, and it can be fitted to one of the ordinary

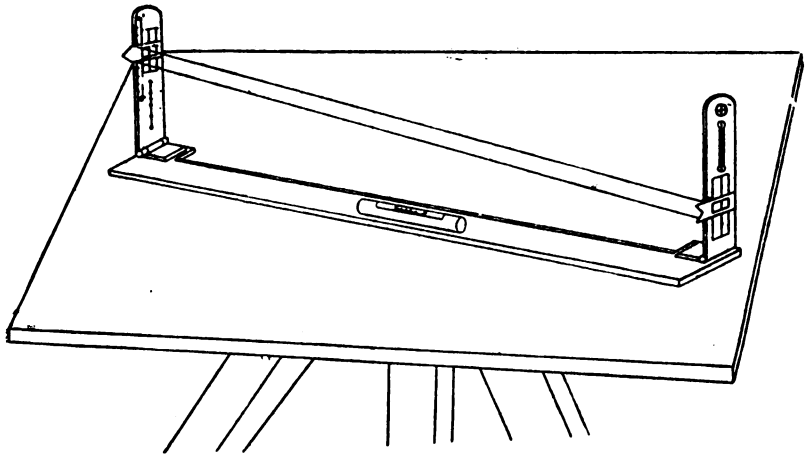

Fig. 8.
Ordinary Plane-Table Alidade fitted with the new attachment.

pattern as shown in Fig. 8. It has been found that very fair work can be done with this simple form when it is in proper adjustment and carefully levelled. However, the telescopic alidade form is much to be preferred, especially as it is difficult to ensure the necessary accuracy in the adjustments and vertical angle readings with this ordinary form.

THE DIARY OF THE WAR OF 1914.

By Colonel F. C. Morgan, late R.A.

(Continued from page 323).

June 19th.

WESTERN EUROPE.—The severe fighting for the roads to Lens and Lille has now continued for over a month. In the sector to the N. of Arras the same story of attacks and counter-attacks daily repeats itself.

In Lorraine German counter-attacks have been successfully met.

Sir J. French reports our having occupied trenches on a front of 250 yards, about Hooge, E. of Ypres, which the enemy had evacuated, owing to other local successes on our side: N.E. of Armentières several mines were exploded, destroying the enemies trenches: At La Bassée British airmen successfully bombarded the electric power station.

EASTERN EUROPE.—The Germans are attacking the Russian defensive line west of Lemberg: but their advance guards were driven back near the Grodek lakes 10 miles from Lemberg.

ITALY.—There is no news of importance from the Austro—Italian frontier. An Austrian naval force appearing at the mouth of the Tagliamento was attacked by destroyers and met with no success.

June 20th.

WESTERN EUROPE.—The French have advanced further towards Souchez; in the sector of the Calonne trench, and on the heights of the Meuse, successes have been maintained. In Lorraine and Alsace they have pressed on their former gains.

EASTERN EUROPE.—The Russians fail to hold the Grodek line of defence, and the fall of Lemberg is anticipated in Petrograd; the fortress has been used as a base of supplies, and not placed in a state of defence from the west.

ITALY.—In the mountainous area of operations on the Italian frontier, rain and fogs have delayed operations. Austrian attacks on the Isonzo front have been driven back.

GALLIPOLI.—The Achi Baba position is described as a small Gibraltar. Reinforcements continually arrive for the troops and an important advance on the peninsula is hoped for.

AIRCRAFT.—Near Roulers a British aeroplane on reconnaissance duty encountered a hostile one, and after a machine gun duel brought the latter to earth.

At Poelcapelle at a height of 4000 ft. 2 officers of the R.F. Corps engaged a large German biplane with 2 engines, and propellers, when at a range of under 200 yards a machine gun duel took place; the German was brought to earth, and the British machine which took fire, landed in a blazing condition, the 2 officers however surviving.

MISCELLANEOUS.—A new War Loan of unlimited extent is issued at par, bearing interest at 4½ %.

June 21st.

WESTERN EUROPE.—The Belgian troops S. of St. Georges captured a German trench.

N. of Arras the enemy after a heavy bombardment attacked at various points, but were repulsed excepting S.E. of Souchez where they regained ground. In the "Labyrinth" the Germans sustained severe losses. In Lorraine 300 yards of ground were gained on the crest E. of Reillon. In Alsace in the Fecht valley all gains were maintained.

EASTERN EUROPE.—In the Baltic provinces there is no change, and only desultory fighting in Poland.

In Galicia in spite of stubborn fighting in certain areas no progress was made by the enemy.

GALLIPOLI.—The Turks gained portions of our trenches on the peninsula on 19th June, but these were retaken by the 5th Royal Scots and a company of the Worcester Regiment to-day. In their general attack the enemy lost heavily, and the French and British carried 600 yards of 1st line trenches on the Turkish left.

June 22nd.

WESTERN EUROPE.—On the night of 21/22nd Dunkirk was bombarded by a long range gun, which fired 14 shells; some civilians being killed.

A violent artillery combat took place between Souchez and Ecurie. Other attacks and counter attacks of minor importance occurred in champagne, on the heights of the Meuse, in the Woevre, Lorraine, and in the Vosges.

EASTERN EUROPE.—The Germans report fighting N. and N.W. of Lemberg, also that W. of Zolkiew the Russians were forced to retreat from their positions.

The Russians have retreated from the Grodek line but are fighting resolutely for the defence of Lemberg.

ITALY.—The Austrians have unsuccessfully attacked the Italian positions at Monte Nero, and also on the Eastern bank of the Isonzo dominating Plava.

MISCELLANEOUS.—In a despatch from Sir J. French dated 31 May, and published to-day, 3772 officers and other ranks are recommended for gallant and distinguished service in the field.

June 23rd.

WESTERN EUROPE.—In the N. of Arras the bombardment on both sides continued throughout the night, the Germans pouring

streams of high explosive shells on the French lines.

In the Vosges at la Fontenelle the enemy after firing 4,000 shells, succeeded in gaining a footing on a front of 200 yards: a feature of the fighting along the whole front is the great expenditure of German shell.

EASTERN EUROPE.—In the Baltic Provinces a fierce battle was fought on the River Ringova on the 21st June, the Russians claiming some progress. In Galicia, Lemberg its capital city has fallen to the Austrian forces, having been previously taken by the Russians on the 3rd Sept., 1914.

The Russians were compelled to fall back from the San river and the attempt to hold the enemy on the Grodek line failing, they retreated East, surrendering Lemberg.

GALLIPOLI.—A Paris communiqué reports severe trench fighting after artillery preparation ; the day ending in a success along the whole line: on the French left it is stated that the British army lent effective support.

NAVAL.—The British Cruiser "*Roxburgh*" was struck by a torpedo on 20th June in the North Sea, but sustained no serious damage and proceeded under her own steam, there being no casualties.

MISCELLANEOUS.—A large military Honours List was published in last night's *Gazette*, including 8 V.C.'s.

June 24th.

WESTERN EUROPE.—Relatively there was calm on the French front, except for bombardments by artillery: the shelling of Arras was resumed.

EASTERN EUROPE.—The new Russian line of defence E. of Lemberg is still in the Austrian territory of Galicia; and owing to the fighting power of the Russians being unimpaired, the enemy is unable to transfer troops to either Warsaw or the Western front.

ITALY.—The Austrians assumed the offensive along their whole line, owing to their receiving strong reinforcements: their attacks however have nowhere succeeded.

June 25th.

WESTERN EUROPE.—There was fighting N. of Arras, in the Labyrinth and near Reims. The Germans attacked also on the heights of the Meuse, in Lorraine and in the Vosges: they also dropped bombs E. of Dunkirk. The night communiqué reports only artillery actions.

EASTERN EUROPE.—In Galicia the enemy made persistent attacks S.E. of Lemberg, along the line of railway to Brzezany which failed according to the Petrograd communiqué. Severe fighting has taken place on the R. Dneister line apparently in favour of the Russians, since the enemy report having to cross to the S. bank of the river.

ITALY.—In the Trentino and Cadore districts of the Italian—Austro frontier, artillery engagements proceed, and the Austrian fort Malborghetto in the Carnia region, has been damaged by shell fire.

AFRICA.—General Botha has occupied Kalkfeld in German S.W. Africa 40 miles N. of Omaruru which was recently taken.

NAVAL.—Lt.-Commr. M. E. Nasmith has been awarded the Victoria Cross for destroying one Turkish gunboat, two transports, one ammunition ship and three store ships, when in command of a submarine, operating in the sea of Marmora.

MISCELLANEOUS.—A Table published in the *Times* shows a total of 2,440 casualties amongst officers of the British, Colonial and Indian Contingents including 741 killed in one month, between the 26th May and 25th June. In the S. African war the total casualties of officers were 2,752, including 701 killed.

June 26th.

WESTERN EUROPE.—The enemy succeeded in gaining a footing of over 200 yards to the N. of Souchez. At Bagatelle, in the Argonne forest a violent attack was repulsed by the French. On the heights of the Meuse fighting lasted all night.

On the 25th the French airmen threw 20 bombs on Douai station 15 miles E. of Souchez doing serious damage.

EASTERN EUROPE.—In N. Poland on the Narew front the Russians were compelled to give way owing to the enemy's annihilating fire.

In Galicia fighting continues along the Dniester line, with varying results to either side.

ITALY.—Austria has sent strong reinforcements to the frontier. The war at some points is now a matter of sieges, whilst the remainder of the conflict is trench warfare as in Western Europe.

AIRCRAFT.—French airmen raided the railway station of Douai, throwing 20 bombs and causing serious damage.

June 27th.

WESTERN EUROPE.—On the N. and central fronts, there were infantry actions. In Belgium and N. of Arras there were violent artillery duels.

EASTERN EUROPE.—In N. Poland near Przasmysl a desperate battle, developing into bayonet fighting occurred and still continues. In Galicia the Russians claim to have captured 2,000 prisoners and 36 officers on the 25th.

ITALY.—Along the Isonzo R. front the Italians are progressing slowly.

NAVAL.—A German submarine has been sunk near Borkum, owing to an explosion on board, the commander and 2 of the crew only being saved.

June 28th.

WESTERN EUROPE.—Nothing of importance occurred during last night beyond 2 attacks at Calonne and Metzeral, which were repulsed. The day passed off quietly on the whole of the front.

A French aeroplane dropped 8 bombs on the Zeppelin sheds at Friedrichshafen.

EASTERN EUROPE.—The Russians have fallen back eastwards on a new line in South Galicia, thus withdrawing from some sectors of the Dniester line. The Germans report their approach to the line of the R. Bug N.E. of Lemberg. The battles recently fought at Bobrka S. of Lemberg, and on the Dniester, were evidently delaying actions on the part of the Russians.

Berlin reports Russian attacks which broke down in the Przasnysz section N. of the Vistula.

AFRICA.—The port of Bukoba on the Western Shore of Lake Victoria Nyanza and on the frontier between Uganda and German E. Africa has been captured by a British force under Brig.-Genl. J. M. Stewart, C.B., in conjunction with an expedition sent from the port of Kisumu on the Eastern shore of the lake.

MISCELLANEOUS.—49 officers, 200 wounded men and 300 R.A.M.C. men arrived in England as exchanged prisoners of war: they stated the first accounts of the German treatment of prisoners were not exaggerated.

U31 German submarine is reported as having sunk 3 British steamers on the 27th and 28th in the west of England.

June 29th.

WESTERN EUROPE.—In the Argonne incessant fighting has taken place at Bagatelle, a shooting lodge 20 miles W. of Verdun in which air torpedoes and grenades have taken part. The aerial torpedo being driven through the air by its own motor and not by propulsion from a charge. In the Vosges a successful attack by the enemy lost some ground to the French, which was regained during the day.

EASTERN EUROPE.—In South Poland on the left bank of the Vistula, the battle in the Ozarow district continued through the night of 26/27th. In Galicia the enemy advanced on Tomaszow and Kamionka (on the River Bug). The Russians continue an orderly retreat, fighting strenuous rearguard actions.

ITALY.—In Carnia the Italian mountain artillery ascending to a high peak, effectively bombarded an enemy encampment on the other side of the Pal Piceolo. Bad weather hinders operations.

MISCELLANEOUS.—The award of 10 Victoria Crosses was announced in the *London Gazette*.

June 30th.

WESTERN EUROPE.—There were artillery actions on the banks of the Yser and to the N. of Arras: and severe fighting in the forest of Argonne, between Binarville and Four de Paris. In the Vosges a new attack on the positions at Metzeral was made.

EASTERN EUROPE.—In the Dniester district in Galicia the enemy strongly reinforced strove to throw into confusion the Russian retreat to the Gnila—Lipa river, but failed and suffered severe losses.

GALLIPOLI.—Sir Ian Hamilton reports that the plan of operations that occurred on the 28th, was to throw forward the left of

his line S.W. of Krithia and to establish a new line facing East on the ground gained. The plan entailed the capture in succession of 2 lines of trenches East of Saghir Dere Ravine and of five to the west. The Australian Corps were ordered to co-operate. The result was a complete success.

The French communiqué mentions that since their success on 21st inst. they have consolidated their positions and repulsed several counter-attacks. On 27/28th the British left, supported by French artillery after an intense bombardment, advanced 1500 metres and took 180 prisoners; a night counter-attack by the enemy was wiped out.

July 1st.

WESTERN EUROPE.—A German attack by a force of 30,000 men was repulsed in the Argonne yesterday. To the North of Arras the cannonading has been violent, and also on the Aisne front. In the Vosges 2 enemy attacks were defeated.

EASTERN EUROPE.—The situation remains unchanged, and in the Shavli region on the Niemen and Narew fronts, and on the left bank of the Vistula there has been a lull.

GALLIPOLI.—Further reports of the part played by the Australian and New Zealand army corps on the 28 June, state the action was commenced by H.M.S. "*Humber*", "*Pincher*", and "*Chelmer*" engaging the enemy's heavy guns. At 1 p.m. the 2nd light Horse Bde. and 3rd Infantry Bde. advanced some 700 yards, and encountered the enemy in great strength: at 2.30 p.m. a counter-attack on the part of the Turks was repulsed, and the troops were all back in their trenches between 4.30 and 5.30 p.m.

NAVAL.—H.M. Destroyer "*Lightning*" (275 tons) was damaged in the North Sea by a mine or torpedo; she returned to harbour, with 14 of the crew missing.

In the Baltic a detachment of German vessels consisting of a battleship, 4 cruisers and torpedo-boats bombarded Windau, and endeavoured unsuccessfully to effect a landing.

MISCELLANEOUS.—The Leyland liner "*Armenian*" 8,900 tons was torpedoed and sunk off the Cornish Coast by the German submarine U 38 on the 28 June.

The Prime Minister stated that the total Naval and Military casualties in the Dardanelles up to 31 May had been 38,636 including 7,423 killed and 6,537 missing.

July 2nd.

WESTERN EUROPE.—During the whole night of 1/2nd, heavy artillery fire proceeded at a number of points on the front, chiefly N.W. of Ypres, at Souchez, and at Verneuil N. of the Aisne: this was followed by an attack by the enemy on the Ablain road at Angres N. of the Bethune Road, which completely failed.

In the Argonne a violent struggle continued through the night

On the evening of the 1st the Germans after intense artillery preparation attacked the positions on the Hilgenfirst in Alsace: the

enemy gained a footing in a third attack, but in the morning the positions were all recovered.

EASTERN EUROPE.—Part of the German force on the Eastern front is pressing up between the Vistula and the Bug. In this region and also farther S. in Galicia, the enemies advance is delayed by stubborn rear-guard actions.

GALLIPOLI.—On the 29 June, the Turks made a strong counter attack against the position captured on the previous day, but were repulsed with heavy losses; H.M.S. "*Wolverine*" aided from the sea. On the next day the French captured entrenchments in front of their position.

ITALY.—The advance in the Isonzo valley is proceeding slowly.

NAVAL.—Off the island of Gothland in the Baltic, a German minelayer chased by 4 Russian cruisers ran ashore.

Four ships were reported as having been sunk in British waters, off the Scillies.

July 3rd.

WESTERN EUROPE.—In the forest of Argonne the fighting continued throughout the night, with the same stubbornness as before, heavy losses were inflicted on the enemy, and the positions were maintained; the Crown Prince having failed to break the line. During the day no more infantry attacks were made.

EASTERN EUROPE.—The Austro—German forces still advance northwards between the Vistula and the Bug.

AFRICA.—General Botha's troops in S.W. Africa have occupied Obavi.

NAVAL.—In the battle off the coast of Gothland 4 Russian and 2 German cruisers were engaged. The enemies cruiser "*Albatross*" was badly damaged and ran ashore.

July 4th.

WESTERN EUROPE.—In the Nieuport region in Belgium, there were lively artillery actions, and also on the Steenstraate, Het Saste front.

In the region N. of Arras, enemy attacks were repulsed, and on the La Haye front and N. of Regniéville.

ITALY.—The situation on the front remains unchanged: but artillery actions are proceeding with intensity against Malborghetto and the Predil Pass in the Carnia region.

GALLIPOLI.—General Gouraud C.-in-C. of the French expeditionary force having been wounded, he is succeeded by General Bailloud.

July 5th.

WESTERN EUROPE.—2 attacks were made by the enemy during the night, on the French positions before Souchez, and also in "The Labyrinth", which were stopped. During the day a German

offensive took place over a front of over 3 miles from Fey-en-Haye to the Moselle: the enemy succeeded in regaining a footing on their old lines on a front of about 5/8ths of a mile.

EASTERN EUROPE.—The Russians announce the stoppage of the enemy's offensive in S. Poland; whilst from Berlin, a defeat of the Russians from Krasnik in the W. to Plonka in the E. is reported. In Galicia our ally has fallen back to the Zlota-Lipa.

GALLIPOLI.—The attacks of the Turks on the allied positions on the night of 29/30th June and on 2nd July, are described in Sir Ian Hamilton's despatch: they all failed, and the enemy suffered losses estimated at 20,000.

AIRCRAFT.—The Admiralty report that on the 3rd inst., 2 aeroplanes of the enemy flew at a great height off Harwich; they were driven off and dropped bombs into the sea. The German account stated they had dropped bombs on Landguard Fort at Harwich.

July 6th.

WESTERN EUROPE.—Sir J. French states there is no change in the situation on the British front since his last report. The enemy has exploded 8 mines at different points, without doing any damage to our trenches. 50 yards of the enemy's front line N. of Neuve Chapelle were blown in, on the 30th June.

At Ypres on 4th July a German sap was blown in by howitzer fire, and a platoon of infantry was advanced to attack; the enemy were driven out with the bayonet with insignificant casualties on our side. On the 5th the Germans rushed a barricade on the Ypres—Roulers railway after a 2 hours bombardment, but the position was recaptured immediately by a counter-attack.

With the aid of French guns and trench mortars, 200 yards of the enemy's trenches were captured and 80 prisoners taken.

EASTERN EUROPE.—Between the Rivers Bug and Vistula, the Austrian offensive E. of Krasnik, was completely checked. The scene of the battle was about 15 miles from the Lublin—Cholm railway: the Russians claim 2,000 as prisoners and 2,000 of the enemy killed. There was no change in the Baltic provinces.

ITALY.—Severe fighting is in progress on the Isonzo front. The reports of successes on either side differ.

July 7th.

WESTERN EUROPE.—To the N. of Arras the bombardment continued all night and 2 attacks against the French at Souchez were repulsed. At the St. Mihiel wedge on the E. bank of the Meuse and 18 to 20 miles S.E. of Verdun, after a violent bombardment, the enemy attacked and succeeded in penetrating in one part, on a front of about 760 yards. A German attack on the E. of the Bois le Prêtre preceded by a deluge of liquid fire was stopped.

EASTERN EUROPE.—The organisation for the production of munitions in Russia is arranged.

GALLIPOLI.—Sir I. Hamilton reports that on the night of the 3/4th all was quiet in the Northern section, but at 4 a.m. a bombardment was started by the enemy which ceased at 6 a.m., it was supported by a fire of 20, 11·2 inch shells.

In the southern section, the Turks opened the most violent bombardment that has been experienced, at least 5,000 rounds of ammunition being fired. In the general attack which followed the principal effort was at the junction of the Royal Naval Division with the French, another attack being made on right of the 29th Division which was wiped out by rifle and machine gun fire. The bombardment died down at 11 a.m.: the result was a complete failure for the enemy; the C.-in-C. also reports our losses as negligible, whilst those of the Turks were very heavy.

The French official report mentions the attack as being the most important one since the enemy's attempts in the beginning of May "to throw us into the sea": the enemies batteries on the Asiatic Coast firing without cessation. At the end of the day 15 allied aeroplanes bombed the Turkish aerodrome at Chanak.

NAVAL.—The transport of Turkish troops to the Gallipoli peninsula is greatly impeded, owing to British submarines in the Sea of Marmora.

July 8th.

WESTERN EUROPE.—Fighting about Souchez continues: also there were severe combats in the Forest of Apremont: and violent bombardments between the Meuse and the Moselle.

EASTERN EUROPE.—Berlin is silent as to the situation in S. Poland and Galicia: Petrograd reports severe fighting on the front between the Vistula and Bug rivers with advantage to the Russians.

ITALY.—During the past 24 hours nothing of importance occurred on the different fronts. In the Upper Adriatic the Italian Cruiser "*Amalfi*" 9,958 tons was torpedoed during a reconnaissance, by an Austrian submarine, and sank, most of the crew being saved.

NAVAL.—It is announced officially in Petrograd that the German pre-Dreadnought battleship was sunk in the Baltic on the 2nd July by a British submarine.

GALLIPOLI.—General Gouraud the French C.-in-C. is returning to France wounded.

July 9th.

WESTERN EUROPE.—Sir J. French reports that all the attempts of the enemy to retake his trenches N. of Ypres have been unsuccessful. To-day after a 2 days and nights bombing duel, the enemy fell back along the canal at Ypres, and our gains were extended: prisoners were taken and the enemies losses were severe.

The French communiqué reports a lively artillery duel round Souchez, during the night, and also a violent cannonade between the Oise and the Aisne. In the Vosges at Fontenelle a marked success was scored, an advance of 760 yards on a front of 650 yards being made.

EASTERN EUROPE.—To-day it is reported that 11,000 prisoners and much war material were captured by the Russians between the 5th and 7th July. On a front of 5 miles N. of Krasnik in S. Poland, the Austrians sustained a crushing defeat.

S. AFRICA.—At 2 a.m. to-day General Botha accepted the surrender by the Governor of German S.W. Africa, of the whole of the German forces : hostilities have now ceased and the campaign has ended. The sea bases of Port Nolloth, Swakopmund, and Luderitzbucht were secured before the campaign began; and after the capture of the capital Windhuk on 12th May, Botha advanced North in June against the enemy, who had retreated up the railway to Otavi, and to the terminus at Grootfontein when they surrendered.

ADEN.—A Turkish raid on the hinterland of Aden was made on the 4th June, by a force from the Yemen. The Aden troops were attacked at Lahej 20 miles distant, being compelled to fall back on Aden.

July 10th.

WESTERN EUROPE.—Nothing of importance has occurred. French aeroplanes dropped 22 bombs and 100 darts on railway stations S.W. of Metz.

EASTERN EUROPE.—On the left bank of the Vistula the Germans have withdrawn from the position captured near Gumlin under a hurricane of fire. On the Lublin front the fighting continues. In Galicia on the Western Bug, the enemy's attacks were repulsed.

ITALY.—Our ally's progress continues.

July 11th.

WESTERN EUROPE.—On the night of 10/11th our army repulsed an attack, which at first had succeeded, but was driven back by an immediate counter-attack. In the French attack on the 8th N. of St. Dié 881 prisoners including 21 officers and a quantity of war material were taken.

To-day has been relatively quiet on the whole front.

EASTERN EUROPE.—The Russian army defending Lublin has now taken 15,000 Austrian prisoners. The Garrison of Osowiec on the night of 9/10th made a sortie destroying the enemies saps.

Vienna reports the situation unchanged.

S. AFRICA.—The German forces that surrendered numbered 204 officers and 3,166 men.

MISCELLANEOUS.—The King visited the Grand Fleet under Admiral Sir J. Jellicoe.

July 12th.

WESTERN EUROPE.—Sir J. French's full despatch is published to-day detailing the 2nd battle of Ypres and the operations in the Festubert region carried out in conformity with those of the French N. of Arras. (See page 253).

Great activity on the night of the 11/12th occurred: and the enemy with the aid of asphyxiating bombs were able to occupy the cemetery at Souchez and portions of the adjacent French trenches: there was fighting in various areas along the whole front, without any appreciable result to either side.

The enemy report that the much-contested cemetery on the road to Arras, S. of Souchez is again in their hands.

EASTERN EUROPE.—The Austrian army in S. Poland is holding its positions and awaiting General Von Mackensen's operations on its right.

ITALY.—In the Carnia region of Italy, the enemy abandoned their advanced positions owing to a strong Italian offensive: the latter also repulsed strong attacks in the Monte Nero zone.

Vienna reports that all Italian attacks failed.

NAVAL.—The German ship "*Königsberg*" was destroyed by shell fire from 2 river monitors the "*Severn*" and the "*Mersey*" on the 4th and 11th July: she had been sheltering up the River Rufigi, in German E. Africa since the 2nd October, 1914, in a position where only shallow draught vessels could engage her. The "*Mersey*" was hit twice, the casualties being 4 killed and 6 wounded.

MISCELLANEOUS.—The German reply to the U.S.A. protest of 10th June, has been received with much disfavour.

In to-day's *Times* a vivid description of the 2nd battle of Ypres, 22 April to 13 May, by J. Buchan from Headquarters is published.

July 13th.

WESTERN EUROPE.—In Belgium the enemy bombarded the French and British lines with asphyxiating shells; further S. they attempted to take positions in the Labyrinth, but were thrown back on their lines.

35 French aeroplanes dropped 171 bombs (3½″) on the railway junction and depôts of munitions of Vigneulles N. of St. Mihiel, causing several outbreaks of fire.

The Crown Prince attacked violently in the forest of Argonne, but the French line was held.

EASTERN EUROPE.—In S. Poland and Galicia the enemy's advance is delayed and the Russians hold a position on heights N. of Krasnik defending the Lublin and Odessa railway.

ITALY.—Venice was again attacked by aircraft on the 10th July, one bomb falling close to the palace of the Doges.

GALLIPOLI.—It is reported that the Turkish losses amount to 135,000.

MISCELLANEOUS.—The Chancellor of the Exchequer announced that the amount subscribed to the New War Loan was 570 millions.

July 14th.

WESTERN EUROPE.—In Belgium after the bombardment of yesterday, the enemy attacked the trenches which had been captured

on the 5/6th by the British, to the S.W. of Pilkem on the E. bank of the Ypres canal, but were easily repulsed.

In the Argonne, the Crown Prince's army has been checked and the French are taking the offensive: the Germans claim a great success in this region.

A French squadron of 20 aeroplanes dropped 24, 90 mm., and 16, 150 mm. shells on the junction station of Libercourt, between Lille and Douai, causing great destruction.

EASTERN EUROPE.—During the recent retreat, the Russians rearguard actions are stated to have been "like a manœuvre," so admirably were they carried out.

GALLIPOLI.—The constant Turkish attacks in massed formations on the allies trenches, have been on all occasions repulsed with heavy losses to the enemy. Enver Pacha is now in command, the German General Von Sanders having been wounded. The enemy have been strongly reinforced with munitions and men, and by daily digging have transformed the region round Achi Baba and Krithia and the plateau Kilid Bahr into a fortress.

July 15th.

WESTERN EUROPE.—All the German attempts to gain a footing on the left bank of the Yser have been unsuccessful.

In the Argonne the fighting was confined to the W. of the forest, the French claiming successes. The day has been relatively quiet.

EASTERN EUROPE.—The enemy have attacked the defences of the River Narew, behind which lies the railway from Warsaw to Petrograd; the Russians retired without accepting battle. The enemy claim to have captured Przasnysz 50 miles N. of Warsaw.

GALLIPOLI.—Sir Ian Hamilton reports the successful assault of Turkish trenches to a depth of about 400 yards on the 12th inst: the French in the meanwhile pushing their right down to the mouth of the River Kereves Dere. The allied fleet cooperated effectively by firing on Achi Baba and also on the Asiatic coast.

July 16th.

WESTERN EUROPE.—Berlin claims a victory for the Crown Prince in the forest of Argonne at Hill 285: the French communiqué however denies this, stating that the hill occupied for a time was recaptured, the enemy incurring severe losses. Attacks of the enemy at Souchez and also in Lorraine have been repulsed.

EASTERN EUROPE.—The enemy advance in the Shavli region and menace Riga. Their armies threaten Warsaw from both the N. and S. The Russians are disputing the passage of the Dneister to the enemy.

AFRICA.—Cameroons. The allied forces have occupied Ngaundere.

July 17th.

WESTERN EUROPE.—Attacks have been frequent on the part of the enemy during the past few days along the front, in spite

of the new offensive on the Russian front which has developed. Sir John French reports nothing important as having occurred, though there has been considerable activity in the front line, and, also heavy bombardments.

EASTERN EUROPE.—A simultaneous offensive on the part of the enemy is in progress along the whole line of 1000 miles. From the Vistula to the Baltic, von Hindenburg commands the whole portion. The Russians claim to have resisted all attacks south of Warsaw: but the enemy claim to have broken the Lublin—Cholm line at Krasnostaw.

ITALY.—The Italian advance on the Cadore frontier continues.

July 18th.

WESTERN EUROPE.—Sir John French reports no change on our front since his communiqué of 9th inst: although there have been no engagements, several mines have been sprung by the enemy and also by our troops: there have been heavy bombardments.

On the 10th, in a small attack N. of Ypres, the enemy gained a footing in the front line, but what was lost, was speedily recaptured by the supports. Again on the 13th the enemy rushed an advanced post on the Ypres—Menin road, but were immediately driven back: further north on the same night, a trench was lost after a heavy shelling, but recaptured; a large quantity of gas shells have been fired by the enemy.

In Artois there was a violent artillery duel round Souchez: and 10 shells of large calibre were fired into Arras. On the heights of the Meuse there were sharp infantry actions.

EASTERN EUROPE.—The Germans principal object at present, appears to be the seizure of the Lublin railway in the centre, by breaking in between the 2 armies at Cholm and Lublin, they hope to force the evacuation of Warsaw.

ITALY.—On the Cadore frontier, the Italians are advancing successfully.

July 19th.

WESTERN EUROPE.—In Belgium the enemy violently bombarded the trenches at St. Georges. In Artois their attacks in the neighbourhood of Souchez were repulsed. They also attacked in Argonne forest S.E. of Bagatelle; in Apremont forest, S.E. of St. Mihiel; and in Lorraine.

The French authorities report that the attempts of the Crown Prince since the 13th July to pierce the French line in the Argonne, have completely failed.

EASTERN EUROPE.—South of Warsaw the enemy are attempting to break through the Russian line on the Lublin—Cholm railway at Krasnik and at Krasnostow, the latter place is stated to have fallen to the enemy. North of Warsaw the Russians are retiring to their defences on the R. Narew.

ITALY.—In the archipelago of Dalmatia an Italian division of cruisers bombarded Cattaro, and on retiring were attacked by submarines, when the Italian cruiser "*Guiseppe Garibaldi*" was sunk.

July 20th.

WESTERN EUROPE.—Sir John French only reports a mine as having been successfully exploded W. of the Hooge Château when 150 yards of the enemy's trenches were occupied. There were artillery actions N. of Arras, near Soissons, and on heights of the Meuse. 6 French aeroplanes bombarded Colmar railway station: and an airship dropped 23 bombs on the German ammunition depôt and station S.E. of Les Eparges.

EASTERN EUROPE.—North and South of Warsaw the Russians are retiring. On the north they have retreated to the R. Narew and the line of fortresses protecting the Petrograd—Warsaw railway. The Bzura—Ranka rivers line of defence, W. of Warsaw has been withdrawn, and a retirement made to the Blonie line near the city. To the South the Russians are endeavouring to hold the Warsaw and Lublin railway; but the enemy have broken through the line south of the railway in 3 places and Krasnostaw has fallen.

ITALY.—On the lower Isonzo the Italians fought a successful 2 days battle between Monfalcone and Trieste, on the Carso plateau; over 2,000 prisoners and a quantity of war material were captured from the enemy.

MISCELLANEOUS.—The Bishop of Khartoum has been appointed to represent the Chaplain-General with the troops under Sir John French's command.

July 21st.

WESTERN EUROPE.—For the last few days nothing of importance has occurred on this front, as regards infantry fighting: but on the night of the 20/21st the enemy attacked the French positions in the forest of Apremont: and to-day there were struggles around Souchez with aerial torpedoes and grenades.

31 airmen bombarded the Conflans-en-Jarny station a junction on the Verdun—Metz railway.

EASTERN EUROPE.—Attacks are being made on the Russian positions and fortresses on the R. Narew, from Nowogrod (at the junction of the rivers Pissa and Narew) to Nowo Georgiewsk guarding Warsaw to the North. North of Nowogrod, the Russians have retired leaving 2,000 prisoners. There was heavy fighting S. of Iwangrod, but the Lublin—Cholm railway is still in possession of the Russians.

ITALY.—A battle is still in progress on the Isonzo, between Monfalcone and Gorizia, the Austrians holding the latter.

NAVAL.—It is announced that Commander Max K. Horton, D.S.O., was in command of the British submarine, which torpedoed the German battleship "*Pommern*" in the Baltic on the 2nd of July.

Verbatim extracts from Sir Ian Hamilton's report on the operations in Gallipoli, covering the period extending from 5th May to the beginning of July, 1915.

At the close of the ten days and ten nights described in my first despatch, our troops had forced their way forward for some 5000 yards from the landing places at the point of the peninsula. Opposite them lay the Turks, who since their last repulse had fallen back about half a mile upon previously prepared redoubts and entrenchments Both sides had drawn heavily upon their stock of energy and munitions, but it seemed clear that whichever could first summon up spirit to make another push must secure at least several hundreds of yards of the debatable ground between the two fronts. And several hundred yards, whatever it might mean to the enemy, was a matter of life or death to a force crowded together under gun fire on so narrow a tongue of land. Such was the situation on May 5, the date last mentioned in my despatch of the 20th of that month.

On that day I determined to continue my advance, feeling certain that even if my tired troops could not carry the formidable opposing lines they could at least secure the use of the intervening ground. Orders were forthwith issued for an attack.

The many urgent calls for reinforcements made during the previous critical fighting had forced me to disorganise and mix together several of the formations in the southern group, to the extent even of the French on our right having a British battalion holding their own extremest right. For the purpose of the impending fight it became therefore necessary to create temporarily a composite division, consisting of the 2nd Australian and New Zealand Infantry Brigades (withdrawn for the purpose from the northern section), together with a naval brigade formed of the Plymouth and Drake battalions. The 29th Division was reconstituted into four brigades, i.e., the 88th and 87th Brigades, the Lancashire Fusilier Brigade (T.F.), and the 29th Indian Infantry Brigade. The French Corps Expéditionnaire was reinforced by the 2nd Naval Brigade, and the new composite division formed my general reserve.

The 29th Division, whose left rested on the coast about three miles north-east of Cape Tekke, was ordered to direct, its right moving on the south-east edge of Krithia, while the Corps expéditionnaire with the 2nd Naval Brigade had assigned to them for their first point of attack the commanding ridge running from north to south above the Kereves Dere. A foothold upon this ridge was essential, as its capture would ensure a safe pivot on which the 29th Division could swing in making any further advance. Communication between these two sections of the attack was to be maintained by the Plymouth and Drake battalions.

During the three days (May 6-8) our troops were destined to be very severely tried. They were about to attack a series of positions scientifically selected in advance which, although not yet joined up into one line of entrenchment, were already strengthened by works on their more important tactical features.

The 29th Division led off at 11 a.m.; the French corps followed suit at 11.30 a.m.; every yard was stubbornly contested; some brigades were able to advance, others could do no more than maintain themselves. Positions were carried and held, other positions were carried and lost; but, broadly, our gunners kept lengthening the fuzes of their shrapnel, and by 1.30 p.m., the line had been pushed forward two or three hundred yards. Here and there this advance included a Turkish trench, but, generally speaking, the main enemy position still lay some distance ahead of our leading companies.

By 4.30 p.m., it became clear that we should make no more progress that day. The French corps were held up by a strong field work. They had made good a point upon the crest line of the lower slope of the Kereves Dere ridge, but there they had come under a fire so galling that they were unable, as it turned out, to entrench until nightfall. The 88th Brigade could not carry a clump of fir trees to their front; company after company made the perilous essay, but the wood swept by hidden machine guns proved a veritable deathtrap. The Lancashire Fusilier Brigade also were only just barely holding on, and were suffering heavy losses from these same concealed machine guns. The troops were ordered to entrench themselves in line and link up their flanks on either side.

At night, save for rifle fire, there was quiet along the whole British line. On the right a determined bayonet charge was made upon the French, who gave ground for the moment, but recovered it again at dawn.

Next morning (May 7) we opened with shrapnel upon the enemy's trenches opposite our extreme left, and at 10 a.m., the Lancashire Fusilier Brigade began the attack. But our artillery had not been able to locate the cleverly sited German machine gun batteries, whose fire rendered it physically impossible to cross that smooth glacis. Next to the right the 88th Brigade swept forward, and the 1-5th Royal Scots, well supported by artillery fire, carried the fir trees with a rush. This time it was discovered that not only the enfilading machine guns had made the wood so difficult to hold. Amongst the branches of the trees Turkish snipers were perched, sometimes upon small wooden platforms. When these were brought down the surroundings became much healthier. The Royal

Inniskilling Fusiliers, of the 87th Brigade, were pushed up to support the left of the 88th, and all seemed well, when at 1.20 p.m., a strong Turkish counter-attack drove us back out of the fir clump. As an offset to this check the Royal Inniskilling Fusiliers captured three Turkish trenches, and a second battalion of the 87th Brigade, the King's Own Scottish Borderers, was sent forward on the left to make these good.

At 3 p.m., the Lancashire Fusilier Brigade again reported they were definitely held up by the accurate cross-fire of batteries of machine guns concealed in the scrub on the ridge between the ravine and the sea, batteries which also enfiladed the left flank of the 88th Brigade as it endeavoured to advance in the centre. Unless we were to acquiesce in a stalemate the moment for our effort had arrived, and a general attack was ordered for 4.45 p.m., the whole of the 87th Brigade to reinforce the 88th Brigade, and the New Zealand Brigade to support it.

Orders were therefore issued to dig in at sundown on the line gained, to maintain that line against counter-attack, and to prepare to advance again next morning.

At 10.15 a.m., heavy fire from ships and batteries was opened on the whole front, and at 10.30 a.m., the New Zealand Brigade began to move, meeting with strenuous opposition from the enemy, who had received his reinforcements. Supported by the fire of the batteries and the machine guns of the 88th Brigade, they pushed forward on the right and advanced their centre beyond the fir trees, but could make little further progress. By 1.30 p.m., about 200 yards had been gained beyond the previously most advanced trenches of the 88th Brigade.

At this hour the French corps reported they could not advance up the crest of the spur west of Kereves Dere till further progress was made by the British. At 4 p.m., I gave orders that the whole line, reinforced by the 2nd Australian Brigade, would fix bayonets, slope arms, and move on Krithia precisely at 5.30 p.m.

At 5.15 p.m., the ships' guns and our heavy artillery bombarded the enemy's position for a quarter of an hour, and at 5.30 p.m., the field guns opened a hot shrapnel fire to cover the infantry advance.

The co-operation of artillery and infantry in this attack was perfect, the timing of the movement being carried out with great precision. Some of the companies of the New Zealand regiments did not get their orders in time, but acting on thier own initiative they pushed on as soon as the heavy howitzers ceased firing, thus making the whole advance simultaneous.

The steady advance of the British could be followed by the sparkle of their bayonets until the long lines entered the smoke clouds. The French at first made no move, then, their drums beating and bugles sounding the charge, they suddenly darted forward in a swarm of skirmishers, which seemed in one moment to cover the whole face of the ridge of the Kereves Dere. Against these the Turkish gunners now turned their heaviest pieces, and as the leading groups stormed the first Turkish redoubt the ink-black bursts of high-explosive shells blotted out both assailants and assailed. The trial was too severe for the Senegalese tirailleurs. They recoiled. They were rallied. Another rush forward, another repulse, and then a small supporting column of French soldiers was seen silhouetted against the sky as they charged upwards along the crest of the ridge of the Kereves Dere, whilst elsewhere it grew so dark that the whole of the battlefield became a blank.

Not until next morning did any reliable detail come to hand of what had happened. The New Zealanders' firing line had marched over the cunningly concealed enemy's machine guns without seeing them, and these, re-opening on our supports as they came up, caused them heavy losses. But the first line pressed on and arrived within a few yards of the Turkish trenches which had been holding up our advance beyond the fir wood. There they dug themselves in.

The Australian Brigade had advanced through the Composite Brigade, and, in spite of heavy losses from shrapnel, machine-gun, and rifle fire, had progressed from 300 to 400 yards.

The determined valour shown by these two brigades,the New Zealand Brigade, under Brigadier-General F. E. Johnston, and the 2nd Australian Infantry Brigade, under Brigadier-General the Hon. J. W. McCay, is worthy of particular praise. Their losses were correspondingly heavy, but in spite of fierce counter-attacks by numerous fresh troops they stuck to what they had won with admirable tenacity.

On the extreme left the 87th Brigade, under Major-General W. R. Marshall, made a final and especially gallant effort to advance across the smooth, bullet-swept area between the ravine and the sea, but once more the enemy machine guns thinned the ranks of the leading companies of the South Wales Borderers, and again there was nothing for it but to give ground. But when night closed in the men of the 87th Brigade of their own accord asked to be led forward, and achieved progress to the extent of just about 200 yards. During the darkness the British troops everywhere entrenched themselves on the line gained.

On the right the French column, last seen as it grew dark, had stormed and still held the redoubt round which the fighting had centred until then. Both General d'Amade and General Simonin had been present in person with this detachment and had rallied the Senegalese and encouraged the white troops in their exploit. With their bayonets these brave fellows of the 8th Colonials had inflicted exceedingly heavy losses upon the enemy.

The French troops whose actions have hitherto been followed belonged, all of them, to the 2nd Division. But beyond the crest of the ridge the valley of the Kereves Dere lies dead to anyone occupying my post of command. And in this area the newly arrived Brigade of the French 1st Division had been also fighting hard. Here they had advanced simultaneously with the 2nd Division and achieved a fine success in their first rush, which was jeopardised when a battalion of Zouaves was forced to give way under a heavy bombardment. But, as in the case of the 2nd Division, the other battalions of the le Régiment de Marche d'Afrique, under Lieut.-Colonel Nieger, restored the situation, and in the end the Division carried and held two complete lines of Turkish redoubts and trenches.

The net result of the three days' fighting had been a gain of 600 yards on the right of the British line and 400 yards on the left and centre. The French had captured all the ground in front of the Farm Zjimmerman, as well as a redoubt, for the possession of which there had been obstinate fighting during the whole of the past three days.

This may not seem very much, but actually more had been won than at first meets the eye. The German leaders of the Turks were quick to realise the fact. From nightfall till dawn on the 9th–10th efforts were made everywhere to push us back. A specially heavy attack was made upon the French, supported by a hot cannonade and culminating in a violent hand-to-hand conflict in front of the Brigade Simonin. Everywhere the assailants were repulsed, and now for the first time I felt that we had planted a fairly firm foothold upon the point of the Gallipoli Peninsula.

Meanwhile in the northern zone also, the Australian and New Zealand Army Corps had strengthened their grip on Turkish soil. Whilst in the south we had been attacking and advancing they had been defending and digging themselves more and more firmly into those cliffs on which it had seemed at first that their foothold was so precarious.

On May 11, the first time for eighteen days and nights, it was found possible to withdraw the 29th Division from the actual firing line and to replace it by the 42nd Division, which had completed its disembarkation two days previously. The withdrawal gave no respite from shells, but at least the men were, most nights, enabled to sleep.

So soon, then, as the troops had enjoyed a day or two of comparative rest I divided my front into four sections. On the left was the 29th Division, to which the 29th Indian Infantry Brigade was attached. In the left centre came the 42nd (East Lancashire) Division, on the right centre stood the Royal Naval Division, and at my right was the Corps Expéditionnaire. Thus I secured organisation in depth as well as front, enabling each division to arrange for its own reliefs, supports, and reserves, and giving strength for defence as well as attack. Hitherto the piecemeal arrival of reinforcements had forced a hand-to-mouth procedure upon headquarters; now the control became more decentralised.

Already, before the new system of local efforts had come into working order, the 29th Indian Brigade had led the way towards it by a brilliant little affair on the night of May 10–11. The Turkish right rested upon the steep cliff north-east of "Y" beach, where the King's Own Scottish Borderers and the Plymouth Battalion, Royal Naval Division, had made their first landing. Since those days the enemy had converted the bluff into a powerful bastion, from which the fire of machine guns had held up the left of our attacks. Two gallant attempts by the Royal Munster Fusiliers and the Royal Dublin Fusiliers to establish a footing on this cliff on May 8 and 9 had both of them failed.

During the night of May 10–11 the 6th Gurkas started off to seize this bluff. Their scouts descended to the sea, worked their way for some distance through the broken ground along the shore, and crawled hands and knees up the precipitous face of the cliff. On reaching the top they were heavily fired on. As a surprise the enterprise had failed, but as a reconnaissance it proved very useful. On the following day Major-General H. V. Cox, commanding 29th Indian Infantry Brigade, submitted proposals for a concerted attack on this bluff (now called Gurka Bluff), and arrangements were made with the Navy for co-operation. These arrangements were completed on May 12; they included a demonstration by the Manchester Brigade of the 42nd Division and by our artillery and the support of the attack from the sea by the guns of H.M.S. *Dublin* and H.M.S. *Talbot*. At 6.30 p.m., on May 12, the Manchester Brigade and the 29th Divisional Artillery opened fire on the Turkish trenches, and under cover of this fire a double company of the 1/6th Gurkas once more crept along the shore and assembled below the bluff. Then, the attention of the Turks being taken up with the bombardment, they swiftly scaled the cliffs and carried the work with a rush. The machine-gun section of the Gurkas was hurried forward, and at 4.30 a.m., a second double company was pushed up to join the first.

Our left flank, which had been firmly held up against all attempts on the 6th–8th, was now, by stratagem, advanced nearly 500 yards. Purchased as it was with comparatively slight losses (21 killed, 92 wounded), this success was due to careful preparation and organisation by Major-General H. V. Cox, commanding 29th Indian Infantry Brigade; Lieut.-Colonel Hon. C. G. Bruce, commanding

1-6th Gurkas; and Major (temp. lieut.-colonel) F. A. Wynter, R.G.A., commanding the Artillery group supporting the attack. The co-operation of the two cruisers was excellent, and affords another instance of the admirable support by the Navy to our troops.

The line held during the period under review by the Australian and New Zealand Army Corps formed a rough semi-circle inland from the beach of Anzac Cove, with a diameter of about 1100 yards. The firing line is everywhere close to the enemy's trenches, and in all sections of the position sapping, counter-sapping and bomb attacks have been incessant. The shelling both of the trenches and beaches has been impartial and liberal. As many as 1400 shells have fallen on Anzac within the hour, and these of all calibres, from eleven inches to field shrapnel. Around Quinn's Post, both above and below ground, the contest has been particularly severe. This section of the line is situated on the circumference of the Anzac semi-circle at the furthest point from its diameter. Here our fire trenches are mere ledges on the brink of a sheer precipice falling 200 feet into the valley below. The enemy's trenches are only a few feet distant.

On May 9 a night assault, supported by enfilade fire, was delivered on the enemy's trenches in front of Quinn's Post. The trenches were carried at the point of the bayonet, troops established in them, and reinforcements sent up. At dawn on May 10 a strong counter-attack forced our troops to evacuate the trenches and fall back on Quinn's Post. In opposing this counter-attack our guns did great execution, as we discovered later from a Turkish officer's diary that two Turkish regiments on this date lost 600 killed and 2000 wounded. On the night of May 14-15 a sortie was made from Quinn's Post with the object of filling in Turkish trenches in which bomb-throwers were active. The sortie, which cost us some seventy casualties, was not successful.

On May 14 Lieut.-General Sir W. R. Birdwood, was slightly wounded, but, I am glad to say, he was not obliged to relinquish the command of his corps.

On May 15 I deeply regret to say Major-General W. T. Bridges, commanding the Australian Division, received a severe wound, which proved fatal a few days later. Sincere and single-minded in his devotion to Australia and to duty, his loss still stands out even amidst the hundreds of other brave officers who have gone.

On May 18 Anzac was subjected to a heavy bombardment from large-calibre guns and howitzers. At midnight of the 18th-19th the most violent rifle and machine-gun fire yet experienced broke out along the front. Slackening from 3 a.m. to 4 a.m., it then broke out again, and a heavy Turkish column assaulted the left of No. 2 Section. This assault was driven off with loss. Another attack was delivered before daylight on the centre of this section; it was repeated four times and repulsed each time with very serious losses to the enemy. Simultaneously a heavy attack was delivered on the north-east salient of No. 4 Section, which was repulsed and followed up, but the pressing of the counter-attack was prevented by shrapnel. Attacks were also delivered on Quinn's Post, Courtney's Post, and along the front of our right section. At about 5 a.m., the battle was fairly joined, and a furious cannonade was begun by a large number of enemy guns, including 12-inch and 9·2-inch, and other artillery that had not till then opened. By 9.30 a.m. the Turks were pressing hard against the left of Courtney's and the right of Quinn's Post. At 10 a.m., this attack, unable to face fire from the right, swung round to the left, where it was severely handled by our guns and the machine guns of our left section. By 11 a.m. the enemy, who were crowded together in the trenches beyond Quinn's Post, were giving way under their heavy losses.

After sunset on June 4 three separate enterprises were carried out by the Australian and New Zealand Army Corps. These were undertaken in compliance with an order which I had issued that the enemy's attention should be distracted during an attack I was about to deliver in the southern zone.

I now return to the southern zone and to the battle of June 4. From May 25 onwards the troops had been trying to work up within rushing distance of the enemy's front trenches. On May 25 the Royal Naval and 42nd Divisions crept 100 yards nearer to the Turks, and on the night of May 28-29 the whole of the British line made a further small advance. On that same night the French Corps Expéditionnaire was successful in capturing a small redoubt on the extreme Turkish left west of the Kereves Dere. All Turkish counter-attacks during May 29 were repulsed. On the night of May 30 two of their many assaults effected temporary lodgement. But on both occasions they were driven out again with the bayonet. On every subsequent night up to that of June 3-4 assaults were made upon the redoubt and at 8 a.m., on June 4, our heavy artillery opened with a deliberate bombardment, which continued till 10.30 a.m. At 11 a.m., the bombardment recommenced, and continued till 11.20 a.m., when a feint attack was made which successfully drew heavy fire from the enemy's guns and rifles. At 11.30 a.m., all our guns opened fire and continued with increasing intensity till noon. On the stroke of noon the artillery increased their range, and along the whole line the infantry fixed bayonets and advanced. The assault was immediately successful. On the extreme right the French 1st Division carried a line of trench, whilst the French 2nd Division with the greatest dash and gallantry

captured a strong redoubt called the "Haricot," for which they had already had three desperate contests. Only the extreme left of the French were unable to gain any ground, a feature destined to have an unfortunate effect upon the final issue.

The 2nd Naval Brigade of the Royal Naval Division rushed forward with great dash; the Anson Battalion captured the southern face of a Turkish redoubt which formed a salient in the enemy's line, the Howe and Hood Battalions captured trenches fronting them, and by 12.15 p.m., the whole Turkish line forming their first objective was in their hands. Their consolidating party went forward at 12.25 p.m.

The Manchester Brigade of the 42nd Division advanced magnificently. In five minutes the first line of Turkish trenches was captured, and by 12.30 p.m., the brigade had carried with a rush the line forming their second objective, having made an advance of 600 yards in all. The working parties got to work without incident, and the positions here could not possibly have been better.

On the left, the 29th Division met with more difficulty. All along the section of the 88th Brigade the troops jumped out of their trenches at noon and charged across the open at the nearest Turkish trench. In most places the enemy crossed bayonets with our men and inflicted severe loss upon us. But the 88th Brigade was not to be denied. The Worcester Regiment was the first to capture trenches, and the remainder of the 88th Brigade, though at first held up by flanking as well as fronting fire, also pushed on doggedly until they had fairly made good the whole of the Turkish first line.

Only on the extreme left did we suffer a check. Here the Turkish front trench was so sited as to have escaped damage from our artillery bombardment, and the barbed wire obstacle was intact. The result was that, though the 14th Sikhs on the right flank pushed on despite losses amounting to three-fourths of their effectives, the centre of the brigade could make no headway. A company of the 6th Gurkas on the left, skilfully led along the cliffs by its commander, actually forced its way into a Turkish work, but the failure of the rest of the brigade threatened isolation, and it was as skilfully withdrawn under fire. Reinforcements were therefore sent to the left so that, if possible, a fresh attack might be organised.

Meanwhile, on the right of the line, the gains of the morning were being compromised. A very heavy counter-attack had developed against the "Haricot." The Turks poured in masses of men through prepared communication trenches, and, under cover of accurate shell fire, were able to recapture that redoubt. The French, forced to fall back, uncovered in doing so the right flank of the Royal Naval Division. Shortly before 1 p.m., the right of the 2nd Naval Brigade had to retire with very heavy loss from the redoubt they had captured, thus exposing in their turn the Howe and Hood Battalions to enfilade, so that they, too, had nothing for it but to retreat across the open under exceedingly heavy machine-gun and musketry fire.

By 1.30 p.m., the whole of the captured trenches in this section had been lost again, and the brigade was back in its original position, the Collingwood Battalion, which had gone forward in support, having been practically destroyed.

The question was now whether this rolling up of the newly captured line from the right would continue until the whole of our gains were wiped out. It looked very like it, for now the enfilade fire of the Turks began to fall upon the Manchester Brigade of the 42nd Division, which was firmly consolidating the furthest distant line of trenches it had so brilliantly won. After 1.30 p.m., it became increasingly difficult for this gallant brigade to hold its ground. Heavy casualties occurred; the brigadier and many other officers were wounded or killed; yet it continued to hold out with the greatest tenacity and grit. Every effort was made to sustain the brigade in its position. Its right flank was thrown back to make face against the enfilade fire and reinforcements were sent to try to fill the diagonal gap between it and the Royal Naval Division. But ere long it became clear that unless the right of our line could advance again it would be impossible for the Manchesters to maintain the very pronounced salient in which they now found themselves.

Orders were issued, therefore, that the Royal Naval Division should co-operate with the French corps in a fresh attack, and reinforcements were despatched to this end. The attack timed for 3 p.m., was twice postponed at the request of General Gouraud, who finally reported that he would be unable to advance again that day with any prospect of success. By 6.30 p.m., therefore, the 42nd Division had to be extricated with loss from the second line Turkish trenches, and had to content themselves with consolidating on the first line which they had captured within five minutes of commencing the attack. Such was the spirit displayed by this brigade that there was great difficulty in persuading the men to fall back. Had their flanks been covered nothing would have made them loosen their grip.

No further progress had been found possible in front of the 88th Brigade and Indian Brigade. Attempts were made by their reserve battalions to advance on the right and left flanks respectively, but in both cases heavy fire drove them back

At 4 p.m., under support of our artillery, the Royal Fusiliers were able to advance beyond the first line of captured trenches, but the fact that the left flank was held back made the attempt to hold any isolated position in advance inadvisable.

As the reserves had been largely depleted by the despatch of reinforcements to various parts of the line, and information was to hand of the approach of strong reinforcements of fresh troops to the enemy, orders were issued for the consolidation of the line then held.

From the date of this battle to the end of the month of June the incessant attacks and counter-attacks which have so grievously swelled our lists of casualties have been caused by the determination of the Turks to regain ground they had lost, a determination clashing against our firm resolve to continue to increase our holding. Only one example each from the French, British, and Australian and New Zealand spheres of action will be most briefly set down so that your lordship may understand the nature of the demands made upon the energies and fortitude of the troops.

1. At 4.30 a.m. on June 21 the French Corps Expéditionnaire attacked the formidable works that flank the Kereves Dere. By noon their 2nd Division had stormed all the Turkish first and second line trenches to their front, and had captured the Haricot redoubt. On their right the 1st Division took the first line of trenches, but were counter-attacked and driven out. Fresh troops were brought up and launched upon another assault, but the Turks were just as obstinate and drove out the second party before they had time to consolidate. At 2.45 p.m., General Gouraud issued an order that full use must be made of the remaining five hours of daylight, and that, before dark, these trenches must be taken and held, otherwise the gains of the 2nd Division would be sacrificed. At 6 p.m., the third assault succeeded: 600 yards of trenches remained in our hands, despite all the heavy counter-attacks made through the night by the enemy. In this attack the striplings belonging to the latest French drafts especially distinguished themselves by their forwardness and contempt of danger. Fifty prisoners were taken, and the enemy's casualties (mostly incurred during counter-attacks) were estimated at 7000. The losses of the Corps Expéditionnaire were 2500.

2. The Turkish right had hitherto rooted itself with special tenacity into the coast. In the scheme of attack submitted by Lieut.-General A. G. Hunter Weston, commanding 8th Army Corps, our left, pivoting upon a point in our line about one mile from the sea, was to push forward until its outer flank advanced about 1000 yards. If the operation was successful then, at its close, we should have driven the enemy back for a 1000 yards along the coast, and the trenches of this left section of our line would be facing east instead of, as previously, north-east. Obviously the ground to be gained lessened as our line drew back from the sea towards its fixed or pivotal right. Five Turkish trenches must be carried in the section nearest the sea: only two Turkish trenches in the section furthest from the sea. At 10.20 a.m., on June 28 our bombardment began. At 10.45 a.m., a small redoubt known as the Boomerang was rushed by the Border Regiment. At 11 a.m., the 87th Brigade, under Major-General W. R. Marshall, captured three lines of Turkish trenches.

On their right the 4th and 7th Royal Scots captured the two Turkish trenches alloted to them; but further to the east, near the pivotal point the remainder of the 156th Brigade were unable to get on. Precisely at 11.30 a.m., the second attack took place. The 86th Brigade, led by the 2nd Royal Fusiliers, dashed over the trenches already captured by their comrades of the 87th Brigade, and, pushing on with great steadiness, took two more lines of trenches, thus achieving the five successive lines along the coast. This success was further improved upon by the Indian Brigade, who managed to secure, and to place into a state of defence, a spur running from the west to the furthest captured Turkish trench to the sea. Our casualties were small; 1750 in all. The enemy suffered heavily, especially in the repeated counter-attacks, which for many days and nights afterwards they launched against the trenches they had lost.

3. On the night of June 29–30 the Turks, acting, as we afterwards ascertained, under the direct personal order of Enver Pasha to drive us all into the sea, made a big attack on the Australian and New Zealand Army Corps, principally on that portion of the line which was under the command of Major-General Sir A. J. Godley. From mid-night till 1.30 a.m., a fire of musketry and guns of greatest intensity was poured upon our trenches. A heavy column then advanced to the assault, and was completely crumpled up by the musketry and machine guns of the 7th and 8th Light Horse. An hour later another grand attack took place against our left and left centre, and was equally cut to pieces by our artillery and rifle fire. The enemy's casualties may be judged by the fact that in areas directly exposed to view between 400 and 500 were actually seen to fall.

On the evening of this day, June 30, the Mediterranean expeditionary Force suffered grievous loss owing to the wounding of General Gouraud by a shell. This calamity, for I count it nothing less, brings us down to the beginning of the month of July. The command of the Corps Expéditionnaire Français d'Orient was then taken over by General Bailloud, at which point I shall close my despatch.

PRÉCIS OF MILITAR WOCHENBLATT.

By Captain A. E. A. Dobson, R.A.

15th July, 1915.

Field Marshal Hindenburg.

Operations south of the Niemen.

Szaki and Koslowa Buda.

Operations north of the Niemen.

The Kurland campaign. 27th April to 8th May. Capture of Libau.

17th July, 1915.

Field Marshal Hindenburg.

The importance of Liban. 23rd May. Rossieny.

14th June. Capture of Kuze, 7 miles N.W. of Szawle.

N.W. Poland. Precarious situation of General v. Zastrow. Dispositions of General v. Gallwitz. 24th February. Przasnysz. Russian advance on Mlawa. 48 Russian companies *v.* 10 German. Russians repulsed. German advance 8th May—12th May. Russian advance on Orzyc and Omulew. 46 attacks repulsed 13th to 23rd May. Russian losses in six weeks estimated at 100,000.

31st July, 1915.

The battle of Stryi."

In this article mention is made of the excellent field fortifications erected by the Russians S. and S.W. of Stryi. Deep trenches fitted with loopholes and well protected shelters adapted to surrounding country. Low wire entanglements in front enfiladed by fire from special advanced positions. As in many cases these trenches were behind crests or woods, the field of fire for the infantry was limited to about 100 yards.

Mention is also made of the demoralising effect produced by the German artillery fire.

The number of officers killed as announced in Prussian (256-284) Bavarian (196-206); Wurtemberg (208-228); Saxon (162-174) and Naval lists (36-41) amounts to 1,104.

PRÉCIS OF MEMORIAL DE ARTILLERIA.

By Major R. H. R. Benson, R.A.

August, 1915.

Mahon: an advanced Naval base.

The considerations governing the choice of principal (or home) Naval bases do not carry equal weight in regard to the choice of an advanced naval base, where geographical position is the most important consideration. Mahon occupies a most important strategic

position as an advanced base in the Western Mediterranean. Tactical advantages of an island of moderate size for defensive purposes. Good points about the harbour at Mahon. Considering the importance of Mahon as an advanced base for Spain, urges the necessity for equipping it properly and for preparing to defend it powerfully.

Chapter II. The necessity for providing the Naval base with permanent defences in order that the fleet may not be tied to its base. Insufficiency of the existing defences of Mahon. Need for super-calibre guns (i.e. over 12 inch) for coast defences; limitations of high-angle fire guns for attacking warships. Advocates the use of 7·5 inch and 6-inch guns for secondary and anti-torpedo boat armament, and discusses the advantages of high sites for batteries. Necessity for good range finding instruments and fire-control arrangements, and for their proper protection.

Chapter III. Possible uses of airships and aeroplanes for attacking naval bases: the rôle of submarines in attack and defence. The difference between the defence of fortified naval bases, and the defence of open coasts against hostile landings. The probability that a naval base will be attacked from the land side rather than from the sea if the enemy can effect a landing within striking distance of the base but beyond the range of its fixed armament. The safest defence against landings on a large scale lies in the opportune intervention of mobile troops acting from a centrally situated base somewhat withdrawn from the coast. Unsuitability of a coast fortress as a base for the mobile troops intended to guard a section of coast line.

Chapter IV. Application of the general principles discussed in Chapter III to the particular case of the Balearic Islands. Mahon, as the naval base, is the centre of the archipelago and the main point to be defended, the other islands not deserving any large outlay. A suggested armament for Mahon, guns, lights, land front defences and mobile armament.

Fortifications in the present war.

Quotes from articles in a German paper the opinion that in spite of the rapid capture of Antwerp, Liege, Reims, etc., it must not be assumed that permanent fortifications are obsolete. The cases of Verdun, Toul and Belfort prove the contrary. But fortifications to be of any value must keep pace with the development of the means of attack which they may be called upon to resist. With the coming of 12-inch and 16-inch siege howitzers large forts have become almost worthless. Forts in future must be small and carefully concealed, and must be supported by powerful artillery, preferably sited outside the forts themselves.

Quotes from a Portugese Military review the opinion that money spent on permanent fortifications is money badly spent. Better to spend it on provision of powerful Artillery which can be used in conjunction with field fortifications as and when required to resist attack. There is no possibility of keeping the position and details of permanent fortifications secret: consequently the enemy can study the best methods of attacking them in advance and can prepare the necessary artillery, etc., for overcoming them. Field fortifications erected after the outbreak of war can be made very powerful and will be in the nature of a surprise for the enemy.

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